Agricultural and Industrial Problems in India

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BY

ALFRED CHATTERTON,
Professor of Engineering, on Special Duty, Madras.

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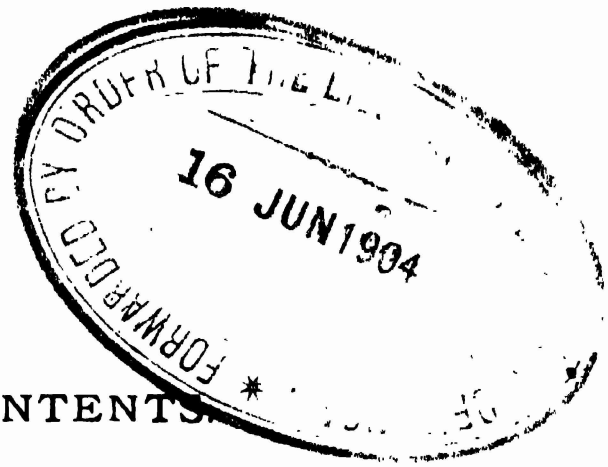

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INTRODUCTION.

THE progress of scientific discovery and invention during the last 15 years has been extraordinarily rapid and the aspect of many industrial and agricultural problems in India has been materially changed by the advances which have been effected. As yet, the importance of these new developments is hardly recognized and most of the papers collected in this little volume have been written at odd times in the hope that they would contribute to the gradual diffusion of knowledge on such matters and that, thereby, they would lead to definite action on the part of those who possess facilities for initiating changes in the desired directions. It cannot, however, be said that much has been accomplished in this way; though at the same time it is satisfactory to be able to record that the results, obtained from what has been done, justify the conclusions which have been drawn in the several papers.

The agricultural experiments still in progress at Melrosapuram promise brilliant financial results and

the work which has there been accomplished by the Rev. A. Andrew is deserving of the highest encomiums. The Irrigation Commission, in their recently published report lay great stress on the importance of extending cultivation under wells and they specifically recommend experiments with engines and pumps. Unless Government act as pioneers in this direction, very little is ever likely to be done; but, on the other hand, if the initiative is taken by Government, and the anticipated results are actually obtained, there is every reason to suppose that private individuals will vigorously continue to develop the use of mechanical appliances and motors for raising water.

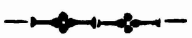
The recent trials of wind pumping engines carried out by the Royal Agricultural Society of England at Park Royal, have drawn attention to the growing importance of these motors and have revealed the immense advances which have been made in recent years under the stimulus of a ready demand for a cheap and reliable engine. In India we cannot afford to neglect these things and, the poorer the country, the greater is the necessity that its capital expenditure should be carefully made with a view to obtaining the highest possible return.

In industrial matters it is satisfactory to record that the Aluminium Department of the School of Arts has been closed after 5½ years' existence and the industry transferred to private enterprise. The whole expenditure on this experiment has been more than recouped and the result justifies the action of Government in putting an old indigenous industry on a new footing and in line with the most advanced practice of Europe.

In regard to the proposals for the Chrome Tanning, sufficient time has not yet elapsed for any definite conclusions to have been established, but the matter has been seriously taken up and the Madras Government have placed at my disposal, sufficient funds for preliminary experiments. Expert tanners regard the idea with favour and it is not unlikely that some of them will not be above adopting the suggestions of an outsider.

In hand weaving but little progress is being made in the extension of the use of the fly shuttle loom and, though it is fairly well known to the weaving community, it is not regarded by them with any favour. There is no doubt that it is a better machine than the native hand loom, and the cost of the most recently devised patterns is small enough; but, nevertheless, it is not popular with native weavers in the South

of India and it is hard to say whether they are aware of any real objection to its use or whether the absolute indifference to its advantages, which is displayed, is merely native prejudice. To improve the warping is still the unsolved problem of hand weaving and, if that can be satisfactorily done, the gradual extinction of the community may be postponed to a very distant date. The survival of hand weaving up to the present day, in spite of the most intense competition from the machine-loom, is due in some degree to its own merits, but in the main it may be attributed to the proverbial inertia of the people of this land.



AGRICULTURAL PROBLEMS.

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WATER-LIFTS.*

In 1895 the Government of Madras appointed a special committee to report on the merits of certain machines for raising water from wells, to which their attention had been drawn by the inventors. Of this committee I was a member, and our reports were officially published as Bulletin No. 32 of the Agricultural Branch of the Department of Land Records and Agriculture. Our enquiries revealed the paucity of accurate scientific data regarding the working and efficiency of the ordinary water-lifts of the country, and disclosed the fact that until such data were collected and carefully studied, it was hardly likely that any material improvement could be effected in the modes of lifting water from wells. Recognising the importance of well irrigation in India I have, during the past twelve months, endeavoured to supply this deficiency and with the assistance of the Board of Revenue, represented by Mr. C. Benson, whose cordial co-operation I have to acknowledge, experiments on a number of typical water-lifts have been made, and results obtained which, it is hoped, will show the direction in which improvement is most likely to be obtained, and the available margin which exists for inventors to work upon.

In the Statistical Atlas of India, the total irrigated area is stated to be 28,334,000 acres, of which 10,140,000 acres, or more than one-third, are entirely dependent upon water drawn from wells. In the Madras Presidency, excluding feudatory and tributary

* Orginally published as Bulletin No. 35 of the Agricultural Branch of the Department of Land Records and Agriculture, Madras 1897.

States and Zemindari lands, the area under irrigation amounted to 5,803,937 acres in 1894-95, and of this area 1,084,060 acres were supplied with water from 427,539 wells, whilst the lands under other systems of irrigation derived a supplementary supply from 139,136 wells. These figures will serve to indicate the magnitude of the interests involved in irrigation from wells, but possibly a clearer idea may be gained from the calculations given below, which, though based on admittedly approximate data, show in greater detail what well irrigation in India means. In Madras, the average area under each well is 2½ acres, but in other Provinces it is larger, and for the whole of India probably averages 4 acres per well, so that the total number of wells must be about two and-a-half million. The cost of constructing 13,337 wells is given as Rs. 16,88,753 in certain returns furnished by the Board of Revenue, Madras, or an average of Rs. 126 each, and as in many places the wells are much deeper than they are in Madras, we may assume, without fear of exaggerating, that the average value of a well in India is Rs. 150, and that therefore the total capital invested in wells amounts to the very large sum of 37½ crores of rupees.

Taking the duty of water for garden or well cultivation at 250 acres per cubic foot per second, the quantity required for over 10 million acres would be 40,000 cubic feet per second, and if we assume that the average depth from which the water is lifted is 30 feet, the work which has to be done amounts to 136,000 horse-power. Cattle, however, do not work more than 8 hours a day, and the efficiency of native water-lifts certainly does not exceed 50 per cent., so that the aggregate horse-power derived from cattle in India and employed in lifting water amounts to 816,000. Assuming that throughout the cultivation season there is an average of two bullocks at work every day at

each well, there would be about 5 million cattle so employed, and each would be doing work equal to one-sixth of one horse-power, a result which is undoubtedly not very far from the truth.

The average quantity of water yielded by each well is, upon the above assumptions, 8,640 gallons per day, a volume so small as to entirely preclude the use of any, but the simplest possible appliances for lifting the water to the surface. Steam-pumping machinery is utterly beyond the means of the ryots, and the force of the wind is too uncertain, and, in general in India, it is too weak to be profitably utilized by wind-mills even of the most modern type. Animals are therefore the only source of power available, and water-lifts in the future must continue to be, as they always have been, worked by cattle. Moreover the Indian agricultural population are so singularly devoid of even the most rudimentary mechanical skill that it is absolutely necessary that machines, intended for their use, should be designed to work without complicated gearing of any kind. As will be seen in the sequel, native methods of lifting water comply with these conditions and possess at the same time, under favourable circumstances, a fairly high efficiency which renders the task of endeavouring to improve upon what is already in use exceedingly difficult.

The enormous amount of energy which is expended on raising water from wells has naturally attracted much attention, and from time to time, in different parts of India, attempts have been made to introduce what were considered improved appliances, but so far no great amount of success has been achieved, and the opinion is now generally held that little or nothing can be done. Of the special reports, which have been prepared on the subject, two at least may be cited. The first is a volume published in 1883 by the Department of Agriculture and Commerce in the North-West Provinces and Oudh, of which the most important

section is a report by Captain Clibborn, B.Sc., an Executive Engineer, who was placed on special duty in connection with the matter, and who, after collecting a vast amount of information regarding existing practices in the North-West Provinces and carrying out a very large number of experiments on the performances of the various types of water-lift in use, expressed in unequivocal terms the opinion the Government could do little or nothing to improve or extend well irrigation in the Provinces. The second report was prepared in Bombay by an Executive Engineer, Mr. F. D. Campbell, after spending three months on special duty, and as the final result of his enquiries he formulated the opinion that nothing can be done to introduce "new or cheaper systems of well construction or of lifts than those which the ryot is already familiar with."

In recent years, in Madras especially, these conclusions have not been accepted by a certain number of practical men who have devoted much time and ingenuity to the production of improved water-lifts and their efforts have at any rate resulted in drawing public attention once more to the water-lift question. The trials conducted by the "Water-lift Committee" showed the necessity of studying the problem scientifically and of taking into account a factor which had hitherto been entirely neglected, viz., the mode of applying animal power. Notwithstanding the number of experiments, the results of which have been published, it was found impossible to compare the performances of the new machines with those obtained from native water-lifts, owing to the insufficiency of the data recorded, and though it did not fall within the scope of the reference to the committee to obtain the necessary figures, it was considered highly desirable that a fresh set of experiments should be undertaken, so as to render it possible to make fairly exact comparative statements on the merits of totally

different forms of water-lift, after trials which should be neither tedious nor difficult to carry out.

The fact that animal power is employed in all forms of water-lift renders it exceedingly difficult to make comparative trials of machines, some worked by one class of bullock in a certain manner and others worked by another, and possibly inferior, class of cattle in a totally different way. Not only have we to take account of the mechanical efficiency of the machine, but also the method by which the animal is made to work must be considered, since the amount of useful energy which can be obtained from an animal depends very largely upon the way in which the muscular efforts are made. The work done by an animal in motion may be conveniently divided into two parts, which we may term internal work and external work, respectively. The latter only is available for useful employment, and, as the sum of the two is probably a constant quantity, it is evident that the more we can reduce the expenditure of energy on internal work, the greater will be the amount available externally. For instance, a bullock walking along a level road expends the whole of his strength on internal work, which simply results in the transportation of his body from one place to another but if we yoke him to a cart the work which he does is partly internal and used in his own movement and partly external and employed in drawing the cart.

What ratio the internal bears to the external work cannot be accurately determined, but there are some facts which enable us to form an approximate estimate. A bullock doing no work can be made to march only a certain number of miles in a day without experiencing undue fatigue. The addition of a moderate amount of external work diminishes the distance which can be travelled, but only to such an extent as to indicate, that of the total muscular exertion the greater part is expended internally.

On a horizontal road and walking at his natural gait, a bullock can exert a draught of one-tenth of his weight for a period of 8 or 9 hours a day. That is to say, he can do work in drawing a cart or a plough along the level equivalent to what he would have to do if he walked up a gradient of 1 in 10. No animal is strong enough to exert a continuous draught equal to one-fifth of his weight, for any length of time, without injury, and a draught equal to one-third of the weight can only be exerted spasmodically and for very short periods, yet a man or a bullock when in training can, with comparative ease, walk up a gradient of 1 in 3 and continue to do so for a very long time if the pace be not too great and if the surface walked on be suitably prepared. It is evident, therefore, that when an animal raises his own weight against the action of gravity, the external work, represented by the potential energy stored in the animal's body, bears a greater proportion to the internal work, which is uselessly expended, than is the case when the external work is due to a pull exerted through a certain distance. For instance, a bullock will walk, along the level, two miles in one hour against a draught equal to one-tenth of his weight and will do, what we may term, a unit of work, equal to raising his own weight one-fifth of a mile; up a gradient of 1 in 3 he would probably walk $1\frac{1}{2}$ miles in one hour and raise his own weight vertically through half a mile, doing $2\frac{1}{2}$ times as much work. Even if he could only do one mile per hour up the slope, the potential energy stored in his body would still be $1\frac{2}{3}$ times as great as if he had been employed in drawing a weight up a vertical shaft by a rope passing over a pulley.

Practically we may assume, then, that an animal, with the same ultimate expenditure of energy, can do twice as much work in raising his own weight against the action of gravity as he can in the only other way it is feasible to employ him. This fact has

long been vaguely known, but has not been made much use of, owing to the difficulty which has been experienced in designing suitable mechanism to embody the idea, without producing a machine both cumbrous and costly. This the Hindu cultivator has recognised, and with more than characteristic ingenuity has devised a compromise between the two methods of working in an exceedingly simple manner, as exemplified in the ordinary country mhote, in which he partially obtains the advantage of the bullocks' weight, by making them run down a steep incline when drawing from the well the bucket full of water, whilst in the picottah, which he himself has to work, the principle has been fully carried out with the result that it is capable of but little improvement, except in the direction of making it a less hazardous machine to work.

A pair of bullocks is a vague term; they may be worth Rs. 40 or Rs. 250, and one pair may easily be capable of doing more than twice as much work as another; yet in previous accounts of experiments on water-lifts no more definite information than this has been forthcoming as to the power employed. Dealing with water-works, engineers are accustomed to state the results of the trial of a pump something in this way. The engine driving the pump indicated 'x' horse power and 'y' gallons of water were lifted against a head of 'z' feet in a certain time. Unfortunately we cannot measure the work done by cattle in absolutely definite units as in the case of a steam-engine, but it is a generally accepted fact that the strength of well-conditioned animals of the same species is roughly proportional to their weight, and it would therefore have added enormously to the value of former experiments on water-lifts if the weight of the cattle used had been ascertained.

The value of a water-lift depends partly upon its mechanical efficiency, and partly upon the efficiency of the method by which

the strength of the animal is utilized when working it. The mechanical efficiency can usually be determined without difficulty, but it does not seem possible to express in numerical terms the ratio which the internal work of the animal bears to that done externally. For practical purposes, however, a constant involving both terms is what is required, and this can be obtained without difficulty. The amount of useful work done in one hour, expressed in foot-pounds, divided by the weight of the animal in pounds, represents the vertical height in feet, to which, by the expenditure of a similar amount of work, the animal's body would be raised. The magnitude of this constant, which may be conveniently termed the *co-efficient of utility*, offers a simple means of stating concisely the value of a water-lift as a machine for getting work done by the agency of animal power. The determination of this constant has therefore been one of the most important objects of the trials recorded in this paper.

In trials of water-lifts, there is liability to a serious error in estimating the out-turn of work from the fact that animals can be made to work at a much faster rate for a short time than they can sustain for a prolonged period. With experience it is possible to judge if animals are seriously over-driven ; or, if experiments can be extended over a sufficient number of hours, over-driving at the start will be revealed by a gradual slakening of the rate of doing work. In the present series of trials, every effort was made to secure that the animals should be driven at their normal speed, and it is believed with success, but as in most cases there was only a limited time for experiments, the rate of working was checked against the animal's weight. Agricultural authorities, in calculating the rations for draught cattle, assume the working day to be eight hours and the rate of doing external work to be 0·25 foot-tons per lb. of weight per hour. This is considered to be the

maximum amount of work which can be obtained, without affecting the health of cattle, and an increase, either in the rate or in the total quantity of work done, soon produces deterioration and sickness. There appear to be no data available as to the amount of work which can be got from cattle in India, but it is probably rather less than in temperate climates, and the value of the figures obtained in these trials lies chiefly in the fact that they enable us to judge at what rate the cattle were worked. It will of course be understood that the more the weight of the animal used, the greater should be the rate at which work can be done, and that the highest rate should be obtained for lifts in which the animal exerts no draught, but simply raises himself up an inclined plane till it overbalances the resistance to be overcome, and useful work is done by the steady descent of the animal under the action of gravity. In this case the rate of working ought to be about 0·5 foot-tons per lb. of weight per hour.

More than 50 years ago a Mr. F. W. Simms communicated to the Institution of Civil Engineers the results of some observations which he had made on the amount of work which horses can do at various rates of working. The average weight of the horses was 1,176lbs. and the results are concisely stated in Table I

TABLE I.

Working day in hours.	Foot-pounds of work done per horse per minute.	Relative amount of work done in a day.
8	23,412	100
6	24,360	78
4½	27,056	65
3	32,943	53

In Captain Clibborn's report on well irrigation in the North-West Provinces are given the results of an extensive series of experiments made on the quantity of water raised from wells of different depths by various methods, from which it appears that the work done by cattle varies very greatly, depending on conditions not explicitly stated, but of which the most important, evidently were, the size and strength of the animals, the depth of the wells aud the type of water-lift employed. In Table II, a few of the results have been extracted and the capacity of the bucket is given to serve as an indication of the size and strength of the cattle as it is evident that only big, powerful beasts could exert a draught of over 500 lbs.

TABLE II.

Depth to water-surface in feet	Capacity of bucket in gallons.	Work done per head per minute in foot-pounds assuming efficiency of lift to be 50 per cent.
57	16·2	9,384
37	28·7	7,426
17	25·2	3,136
12	21·8	2,490
53	47·7	11,678

In the same report, it is stated that with men working the dhenkli the useful effect obtained averaged 1,120 foot-pounds per minute, which would mean that, after due allowance had been made for the imperfect efficiency of the machine, the men were doing about 12 foot-pounds of work per lb. of weight per minute.

In Table III the results of the experiments made in Madras are collected together, and sufficient details given, to show that the variations in the out-put of work are mainly due to the different methods of making use of animal power, and it will be seen that they occur exactly as one would be led to expect from the conclusions arrived at when discussing this point.

TABLE III.

Name of lift.	Nature of work.	Weight of cattle.	No.	Foot-pounds of work done per minute per animal.	Foot-pounds of work done per minute per lb. weight.
		lb.			
Stoney's double mhote.	Draught in a circle, intermittent.	1,146	1	12,060	10·52
		1,438	2	5,410	7·52
		1,146	1	10,308	9·00
Single mhote by Subba Row.	Draught down an inclined plane.	1,348	2	12,180	18·07
See-saw water-lift.	Walking up an inclined plane and reversing.	700	1	9,625	13·75
Sultan Mohideen.	Draught in a straight line and reversing.	1,596	2	6,425	8·05
Andrew's Persian wheel.	Draught in a circle continuous.	985	2	6,695	13·58
Single mhote, Bellary.	Draught down an inclined plane.	2,688	4	12,225	18·20
		2,058	4	5,762	11·21
Single mhote. Coimbatore.		774	2	6,180	15·99
Do.		1,320	2	9,430	14.29

The figures obtained with picottahs worked by men are very striking, especially when it is borne in mind that the work of one man is almost entirely confined to guiding the bucket rod and emptying the bucket, and that only the two men perched on the see-saw lever are employed in lifting the water. Compared with the dhenkli, in which the water is raised by pulling with the arms at the end of a balanced lever, the resultant effect is more than twice as great.

TABLE IV.

Name of lift.	Nature of work.	No. of men.	Weight of men in lbs.	Foot-pounds of work done per man per minute.	Foot-pounds of work done per minute per lb. weight.
Picottah ..	Walking on see-saw lever.	3	308	2,610	25·4
		3	331	2,737	24·81

With the exception of the Persian wheel and modifications such as the chain pump, all the water-lifts used on wells in India consist essentially of a combination of two distinct parts. They are (1) a bucket or buckets for holding the water and (2) an arrangement of some kind by which animal power can be conveniently applied to do the work of raising the full buckets from the well. The buckets are usually made either of leather or iron and may be divided into three classes: (1) a simple leather bag such as is used very largely in Northern India, which requires a man to be specially stationed at the mouth of the well to tilt it over to discharge its contents, or a plain iron bucket or dish of the type

generally used with picottahs; (2) cylindrical iron buckets suspended from stirrups so as to automatically tilt over and fill when lowered into the water, but which require a tilting bar or some equivalent device to empty them, (3) leather or iron buckets fitted with valves. The most ingenious and simple of all these is the common leather mhote, used all over the South of India which consists of a roughly hemispherical leathern bag, suspended from an iron ring and fitted at the bottom with a leather trunk or discharge pipe, the end of which is held by a separate rope above the level of the water in the bag, whilst the latter is being drawn up the well. The ropes are so adjusted that on reaching the top of the well the bag continues to rise whilst the trunk is drawn inwards, with the result that the water is rapidly and completely discharged. Of iron buckets fitted with valves various forms have been proposed, but the only one, that has so far obtained any vogue, is that used with the Sultan water-lift; it is cylindrical in form with a flat bottom, in which is placed a large flap valve opening upwards when the bucket enters the water, and kept closed by the pressure of the water on it during the ascent, till at the top the valve is raised by a system of levers, which are depressed by coming into contact with a fixed stop.

Of possible mechanical arrangements for applying animal power to raise the buckets an indefinite number could be devised, but, owing to the necessity for extreme simplicity and cheapness, there are few that can be considered of any practical importance. A single bucket, suspended by a rope passing over a pulley, fixed over the mouth of the well, and attached directly to a bullock's yoke is the simplest and almost universal way of working throughout India and when the details are arranged to suit the local conditions the single mhote, as it is called, can hardly be surpassed by any more elaborate method. When two buckets are use

they can be made to balance one another by carrying the ropes round the drum of a gin or whim in opposite directions, so that when one ascends, the other descends, as exemplified in the ordinary double mhote. Reversing gear, to obviate the necessity of making the cattle turn round after each bucket is emptied, could easily be provided, but would seldom be used as it would render the whim too costly to construct. By the use of bevil wheels, the whim can easily be adapted to work Persian wheels and allied types of water-lift, which continuously revolve in the same direction. In the Sultan water-lift, the buckets are balanced by being suspended at the ends of a rope which is carried over a series of pulleys so arranged that a pair of bullocks can be yoked directly to the rope, which when pulled in one direction raises one bucket and when pulled in the reverse direction raises the other bucket. Lastly there is the picottah with its balanced lever worked by men and the various modifications of it which have been proposed to render it suitable for employment with cattle.

Experiments have been carried out either by the water-lift committee or by Mr. Benson and myself since the submission of its report on all the types of water-lift enumerated above, but no attempt was made, nor was it deemed desirable, to experiment with pumps and other devices of modern mechanical engineering, as the investigation has been purposely confined to appliances used by ryots or likely to come within the scope of their very restricted resources.

Methods of measurement employed in the experiments:—All weights were determined and draughts measured with a Salter's Spring Balance, recording to 500 lbs. and indicating differences of half a pound, which, previous to the commencement of the experiments, was tested with dead weights. Measurements of

draught and friction were made by inserting the spring balance which was used as a dynamometer in the line of action of the forces exerted by the bullocks, and employing a number of coolies to work the lifts in their place. In machines like water-lifts which of necessity are somewhat roughly constructed, no great amount of labour is expended on fitting the moving parts together; and, in consequence, the working is not perfectly smooth and the friction varies considerably in a single operation of the machine. The measurement of draught is, therefore, not very easy and the results are, in every case, the mean values obtained from a large number of observations. In most instances the average quantity of water brought up by a bucket was measured by passing the water into a tank of known dimensions and counting the number of buckets required to raise the water-level to an amount which was carefully measured. The tank was always filled and emptied several times and the mean result was undoubtedly very accurate. In one or two instances no tank could be procured and the water was measured in a rectangular trough dug in the ground, and, with proper precautions taken to ascertain the loss due to percolation, it was found a satisfactory method. The cattle employed during the trials were in every instance weighed on platform weighing machines, the wells chosen for the experiments being specially selected with reference to the facilities for weighing in the neighbourhood.

Stoney's water-lift:—The principal feature in this lift is the employment of buckets of wrought iron suspended in a stirrup by two adjustable pivots attached to the bucket very slightly above the centre of gravity of the bucket when full of water. The mouth of the bucket is inclined and the lower ends of the stirrup are turned outwards and formed into rings sliding on steel wires which are suspended in the well from screwed eye-

bolts attached to the framing above. The wires are fastened by some convenient means to the bottom of the well and act as guides to the bucket ascending and descending and prevent it from either turning round or swaying to and fro, and thus striking the sides of the well or the second bucket. On the bucket being lowered into the water it turns horizontal and as it sinks fills with water. On being drawn up it assumes a vertical position and rises steadily till the discharging level is reached, when the upper side of the inclined mouth comes into contact with an iron bar fixed across the framing of the lift and the stirrup continuing its upward motion causes the bucket to revolve about the point of contact of the bucket with the iron rod, and thus discharges its contents into the delivery trough. The lift was worked by carrying the ropes which hold the buckets over guide pulleys to a whim. Two buckets were attached and the ropes arranged so that as one bucket ascended the other descended, and the dead weight of the buckets was balanced. The whim consisted of a drum built of wood and was carried by an iron spindle on the top of a post firmly built into the ground. The bullocks worked at the end of an arm which was 3·85 times the radius of the drum. The whim was worked alternately in one direction and the other, the cattle being made to turn round whilst the bucket was discharging its contents.

Improved Single Mhote of M.R.Ry Subba Rao :—

The improvement on the ordinary single mhote is effected by attaching a rope to the draught rope and carrying it on to the large drum of a kind of windlass erected at the end of the inclined plane and at a considerable height above the level of the end of the run. Ropes wound round two smaller drums, one on each side of the large drum, carry weights which balance the weight of the empty bucket so that at the end of a lift

as soon as the bucket is emptied the draught rope automatically rises in the air and the bullocks are able to turn round and walk up the inclined plane in a natural easy manner instead of being forced backwards as with the common plan. The improvement effected is undoubtedly very considerable as not only is the weight of the empty bucket balanced but the animals are also spared the cramped and unnatural backward walk up a steep incline which probably tires them more than their exertions in drawing the bucket out of the well.

See-saw Water-lift of M. R. Ry Subba Rao :—

In this form of water-lift the bullock is made to walk along a platform supported on a roller and by his weight it is caused to oscillate up and down. Two ropes are attached to one end of the platform and wound round two small drums forming part of a windlass, round the large drum of which a rope working an ordinary single mhote is passed. The platfrom is not supported in the middle but at some distance therefrom, so that the working end of the platform greatly preponderates and the bullock has to walk to the free end of the platform to tilt the longer segment up and lower the bucket into the well. To diminish the shock, when the free end falls and the bucket is lowered into the water, iron rails are fastened underneath the platform by a short chain so that just before this end of the platform reaches its lowest position the rails rest on the ground and their weight ceases to act and thereby the platform comes to rest more gently than would be the case if the velocity of descent continued to accelerate to the very end.

Single mhotes.—Experiments with single mhotes were made at Palladam in the Coimbatore District, where they are worked with a single pair of cattle, which are trained to walk backwards up the ramp. The slope of the run is therefore limited to 1 in 5

which is about the maximum that the cattle can be backed up. At Bellary, where experiments were also made, the lift is usually worked with two pairs of cattle, each pair drawing up alternate buckets of water. At the end of the run, the rope and bucket are detached from the yoke and fall back into the well, assisting the driver, who grasps the end of the rope, to return up the steep slope, whilst the bullocks turn round and walk up a side path, which is usually not quite so steep as the ramp. When the bucket is again in the water, the second pair of bullocks are hitched on to the rope and drop another bucket full of water whilst the first pair are leisurely walking up the incline, so as to be ready at the top by the time the driver returns with the rope. With this system of working, it is possible to make the slope of the ramps very steep and the gradient is usually from 1 in $2\frac{1}{2}$ to 1 in 3. The weight of the bullocks is therefore more effcetively utilized, and a much larger bucket can be used than in the Coimbatore District.

The modification of the single mhote invented by M. R. Ry. Subba Row enables most of the advantages of this system of working to be obtained with one pair of bullocks. Moreover, the bucket is balanced, but it is doubtful if this contributes any real increase to the efficiency of the lift, as the friction of the extra pulleys absorbs power and more work is thrown on the driver since the unbalanced bucket materially assits the driver in climbing the steep ramp.

The Persian wheel.—Mr. Andrews, a missionary of the Free Church of Scotland stationed at Chingleput, has erected a form of Persian wheel at the Christian Pariah Settlement of Melrosapuram which he invited me to test. It is built on a framing of old railway rails over a circular well about 24 feet 6 inches in diameter. The rotating drum was 6 feet in diameter and 3 feet 8 inches

wide and carried a double chain of sheet iron buckets each holding 1·80 gallons. The axis was prolonged on one side and driven through a pair of bevil wheels by a whim of the ordinary type. Each bucket was provided with a leather flap valve to permit of the escape of air from the descending buckets as they entered the water. The design was carefully worked out and the water-lift was very strongly made, so that it worked very satisfactorily during the trial.

The Sultan water lift.—This is a direct draught water-lift with balanced buckets, the details of which have been very ingeniously worked out, but the paramount necessity for keeping the cost down has resulted in the use of an unsatisfactory system of construction, which prevents to some extent the full advantages of the design being realized. The buckets are fitted with valves, as already described, which when new are water-tight; but in ordinary daily use they soon get slightly out of order and then leak considerably. Trials were made on one which had been put up in a garden in Tondiarpett to the north of Madras by M.R.Ry. Sundaram Sastri and on one, which has recently been erected near Bellary, in a garden belonging to M.R.Ry. Aerada Rudrappa. The only important difference between the two lifts was that the former was fitted with hemp ropes and the latter with wire ropes. I should have preferred to have tested a water-lift under the management of the makers but, though I offered to do so, they declined to place one at my disposal.

In the following tabular statement (Table V) are given the results of all the trials which I have made. None of the trials were very prolonged, but they were all made under normal working conditions, and the results are only so much better than would ordinarily be obtained in practice as may be fairly ascribed to the fact that care was taken to have the water-lifts in good working

order and the cattle in good condition and that no time was wasted whilst the trials were in progress. The results are strictly comparable and represent the performances of each water-lift under favourable conditions.

The calculation of the efficiency of some of the water-lifts was a very simple matter since the work done by the animals could be measured just as easily as the energy which was stored in the water lifted; but in other cases, which will now be discussed, considerable difficulty has been experienced and the values tabulated are only approximate. In the see-saw water-lift of M.R.Ry. Subba Row, the efficiency when moving very slowly was found to be 59·6 per cent., but at the working speed it was impossible to determine it, and it has therefore been assumed as 50 per cent. which cannot be very far wrong. In the various forms of single mhote, the energy expended by the bullocks has been estimated by adding to the work done on the bucket rope, the work done by the bullocks in lifting their own weight up the incline during the return journey. About the latter quantity there can be no question, but about the former there is some ambiguity due to the fact that the tension in the draught rope is partly caused by the muscular exertion of the animals and partly by a portion of their weight being thrown on to the yoke during the descent of the incline. The importance of the latter quantity increases with the gradient of the run and on a very steep incline enables a pair of bullocks to exert a draught much in excess of what they are capable of on the level. If allowance were made for this, the efficiencies would work out somewhat better; as a portion of the work done, whilst the bucket is hauled up, is due to utilizing some of the energy stored in the animals' bodies when they stand at the head of the incline; but this potential energy only represents part of the muscular energy

developed in the return journey and it is in fact impossible to accurately calculate the efficiency of this lift.

Compared with the *co-efficient of utility* the actual efficiency is a matter of no great importance and it has been thought better to adopt the method given, which is an approximation to the truth, rather than a more complicated one based on assumptions which are not capable of experimental proof. The efficiency of the picottah is very difficult to estimate owing to the rapid movements of the men on the oscillating lever and to the fact that the third man, whose duty is chiefly to guide the bucket rod and empty the bucket, does very little of the work of lifting the water. It is usually stated to be 80 per cent., which is probably correct if only the energy given out by the men who work the lever be taken into the account, but it is certainly much less (about 60 per cent.), if it be considered to be a machine worked by three men.

From the experimental results presented in Table V, it seems justifiable to draw certain conclusions, of which the most important is undoubtedly that the native methods of lifting water under favourable conditions have not not yet been surpassed by the best and most improved inventions of recent years. The mechanical efficiency of modern water-lifts is higher, but the mode of applying animal power, to which sufficient attention has not been paid, is distinctly inferior, save in one case, and the final result is, that as yet, no advance has been made which will in any degree compensate for the increased cost of the new water-lifts. The see-saw water-lift of M. R. Ry. Subba Row alone seems to offer prospects of being developed into something which will be materially better than anything at present in existence. The machine examined by the water-lift committee was mechanically very imperfect, yet the *co-efficient of utility* obtained was very

high, and as it demonstrated clearly the possibility of using cattle to work oscillating platforms, it must be regarded as the first step in what will probably ultimately prove the direction in which the greatest improvement can be made.

Stoney's improved double mhote is undoubtedly, from a mechanical point of view, the best water-lift that has yet been constructed and it has accordingly been made the subject of more extensive experiment than any other. The efficiency is very high and does not appear to be capable of any further improvement, but the animal or animals have to walk in a circular path and are in consequence unable to exert as powerful a draught as when walking straightforward. This is particularly the case if two bullocks are yoked to the revolving arm when the inside bullock works under great disadvantages and most of his energy appears to be consumed in *internal* work. Probably the best results would be obtained with two comparatively small bullocks yoked to separate arms, radiating from opposite sides of the drum so as to balance one another; but if this would necessitate two drivers the increased cost would more than counterbalance the improvement in the conditions of working. The time wasted whilst the bullocks are turning round at the end of each lift is a serious defect especially on low lifts when it occupies a very considerable portion of the working cycle and it materially increases the amount of energy wasted in *internal* friction. With a single bullock of exceptional size, the *co-efficient of utility* is the highest that has been recorded but, with a pair of animals of average size, the figure is reduced by more than one-third, clearly demonstrating, if proof, indeed, be needed, that they were working under unfavourable conditions.

The Sultan water-lift was the subject of experiment on two occasions, once in Tondiarpett under very favourable circumstances as it had been in use for eight months and the animals were

a very fine pair of bullocks that had been thoroughly trained to the work, and once near Bellary on the most recent type of lift, but with animals which were apparently scarcely strong enough and in consequence worked unsatisfactorily. Unfortunately their weight could not be determined as the owner was unable to allow them to be marched into Bellary to be weighed and the observations have therefore not been included in the tabular statement. The lift possesses two very serious defects which are rendered more apparent by the light construction of the parts: (1) The buckets are filled and emptied by means of a valve, which is liable to get out of order and leak, and which at all times requires a strong pull to depress the lever which opens it when the full bucket is drawn up to the discharging point. (2) The draught is direct and is exceedingly heavy, being equal to the weight of water lifted, the weight of the bucket and the force necessary to overcome the resistance of the rope passing over a number of small iron guide pulleys. The buckets are supposed to be balanced and are so except near the end of each lift when the empty bucket sinks into the water, but the friction of the ropes is so great that the weight of the empty bucket is not more than sufficient to drag the length of slack rope to which it is attached back into the well. The lift near Bellary was supplied with 30-gallon buckets and I worked it with twelve coolies through the dynamometer. The buckets discharged about 27 gallons and the pull averaged 370 lbs. towards the well and 350 lbs. away from it, and at the end of each lift rose to 500 lbs. due to the force which had to be exerted to hold the bucket of water in the air and depress the levers which open the valve against the pressure of water on it. Similar results were obtained in Tondiarpett, though the figures were smaller, as 25-gallon buckets were in use. Only the very highest class of cattle can exert such

heavy draughts and even upon them the work tells very severely and they rapidly deteriorate. The draught could of course be lessened by the use of smaller buckets, but the out-turn of water would be correspondingly decreased and the percentage of power wasted in friction would rise so much as to make patent the defects of this method of raising water. The use of larger guide pulleys, a more rigid system of construction and the introduction of a simple system of pulley blocks to diminish the draught by one-half, would increase the efficiency of this water-lift very materially, but at the same time would add so largely to the cost as to render it prohibitive.

The Rev. Mr. Andrew's Persian wheel, which was the first he had made, possesses the great advantage that the cattle do not have to reverse the direction of motion of the whim at frequent intervals, and that consequently no time is lost or energy wasted in useless work. It was well constructed and though capable of minor improvements it may be taken to represent fairly the capabilities of this class of water-lift. The continuity of action renders it extremely suitable for shallow wells in which the water-level varies but little and for such conditions a smaller wheel and smaller, but more numerous, buckets would undoubtedly increase the efficiency. From a ryot's point of view it is too costly, and contains too many working parts, to ever have a chance of being extensively used in this country in any other than the crude form already in use in the north.

The double mhote is inferior to Stoney's[9] modification which has already been discussed and its defects are most conspicuous on deep wells as the motion is so slow that the leakage from the leather discharging trunks—and they always do leak more or less—becomes a serious matter, and a bucket which starts on its upward journey full of water often arrives more than half empty.

It has been extensively tried in certain districts and has answered well when care was taken to keep the buckets in very good order, but that they should be so maintained for any long period is more than could be expected from the ryots of this country and the troubles from leakage have therefore caused the double mhote to be regarded with disfavour.

The two systems of working the single mhote as practised in Coimbatore and Bellary, and known in Northern India by the terms *Lagor* and *Kili*, respectively, have already been described. It is difficult to say what circumstances have determined the ryots in their choice between these two systems as they are often to be found working on apparently the wrong system, but it is easy to see that for shallow wells and small cattle the time lost, in detaching the cattle at the end of each lift and attaching another pair, is not compensated for by getting rid of the necessity for backing the cattle up the incline. With a shallow well and a small bucket or bag, each lift represents the expenditure of only a small amount of work whilst with a deep well and a big bucket, a large amount of work is done in each cycle of operations. With the heavy cattle, which must necessarily be employed where buckets of large capacity are used, there is probably greater difficulty experienced in getting them to back up the inclines and therefore more time wasted and more fatigue incurred than is usual with small cattle. Where the ryots are poor and the cattle undersized the *Lagor* method of working is often only adopted, because they cannot afford to work *Kili*, and it may be generally laid down that the first system is best suited to shallow wells, probably under 25 feet in depth, and the second system to deep wells espicially when they are worked by heavy cattle. The modification in working due to M. R. Ry. Subba Row will probably be found to be of the greatest use in places where the

Kili system is not used,either from want of a sufficient number of cattle on the part of the ryots, or because the wells are of small capacity and too rapidly exhausted when more than a single pair of cattle are worked on them. To obtain good results with the single mhote, it is necessary that the capacity of the bucket should be suited to the size of the cattle and the gradient of the run, and it is evident that in many cases this is not so, with the result that the external work done bears a small ratio to the total muscular energy developed. Where the proper system of working is adopted and the capacity of the bucket is suited to the weight of the cattle, the single mhote is an exceedingly simple, cheap and effective water-lift and is especially convenient from the fact that a varying depth of water in the well causes absolutely no trouble whatever in working. Yet it is not without its disadvantages, and the ryots would gladly welcome any suitable substitute for leather in the discharging trunk, so as to be able to dispense with the necessity of employing chucklers to repair it. Stout canvas has been used in some instances with great success, both in respect to durability and cheapness, and if a knowledge of this fact was widely diffused, it would confer no small benefit upon the ryots of Southern India. So far as I am aware self-filling iron buckets have not been tried with the single mhote though there seems to be no reason why on Stoney's system, at any rate, they should not be a success.

In conclusion, it seems desirable to attempt some estimate of the cost of raising water by means of cattle. A careful study of the figures given in Table V leads me to the conclusion that under favourable circumstances Indian cattle will do about 1·75foot-tons of useful work per pound-weight per day of 8 hours, so that to develope one sixth of one horse-power the animal would have to weigh 653 lbs. and this is probably above

the average weight of cattle employed on water-lifts; but assuming that these figures are approximately correct, it is not difficult to calculate the cost of lifting water. A pair of animals, each doing effective work to the extent of one-sixth of a horse-power, will raise 64,000 gallons one foot high per hour; or, from a depth of 25 ft. will raise 20,480 gallons per day of 8 hours. A pair of such bullocks would be worth Rs. 100, the cost of feeding them would be at least Rs. 10 a month, and the wages of a man to look after them, Rs 5. The renewals of water buckets, ropes and the gear at the head of a well would amount to Rs. 2 a month and the depreciation in the value of the cattle to one rupee a month, making a total of Rs. 18. per month. Assuming that there are 24 working days in the month, the cost per working day amounts to 12 annas and, for this sum, 20,480 gallons of water can be lifted 25 feet, or 42,600 gallons one foot high for one anna. Or, put in another way, it will cost 13 annas 3 pies to raise enough water from a depth of 25 feet to cover an acre of land with one inch of water. This estimate is undoubtedly a low one and in many cases the cost is considerably greater, whilst when cattle food is cheap it may be slightly less. Broadly, therefore, we may take it that the cost of a one-inch watering per acre for a lift of 25 feet varies between 12 annas and Re. 1. It is seldom however that these expenses are defrayed in cash. The ryot breeds his own cattle and from the land cultivated their food is wholely or partly obtained, whilst the servant who looks after them receives the greater part of his wages in kind. Any considerable extension of well cultivation in a few years would materially change this primitive state of affairs, for there is neither capital nor labour available to allow of any rapid increase in area and both capital and labour will have to be provided. If the former is forthcoming mechanical appliances may be confidently counted upon

as efficient substitutes for both animal and human labour. To provide the data to demonstrate this, has been the object of this investigation since at a very early stage in the enquiry it became evident that little could be done to improve existing methods of applying animal power to raising water.

UNDERGROUND WATER-SUPPLY.

During the past few years India has been visited by two famines over widespread areas and several severe droughts which have affected smaller but still very considerable tracts of country. The agricultural population, and those directly dependent on them, have been thrown out of employment and their slender resources being soon exhausted, in enormous numbers they have been forced to seek for the means of subsistence on the relief works which Government have opened. In good or even average years the exports of wheat and other food stuffs from the country prove that the area under cultivation is still in excess of the requirements of the rapidly-growing population. In famine years the surplus produce of the non-affected parts of the country is diverted from the export trade and carried by the railways to places where there is a local deficiency, so that in the worst years there is enough food for all and it is simply the poverty of the people that puts it beyond their reach. A succession of favourable seasons would materially improve the condition of the land-owning classes but it would lead to no accumulation of grain in the villages and the labouring classes during these years of plenty will simply increase in numbers and the next failure of the rains will find them as now—only more of them—in complete destitution.

The problems which Indian Administrators are called upon to face in the immediate future, to combat with this deplorable

* *Indian Review*, June 1900.

state of affairs, are very difficult and the solution of them will make as heavy demands upon the energy and resources of the executive as have ever been made in the past. It is generally agreed that the most pressing necessity is the development of industrial occupations whereby new sources of wealth may be opened out and the land relieved of the excessive proportion of the population which is now entirely dependent on it. The mineral wealth of the country must be utilized to supply its own requirements, new industries must be introduced and old ones resuscitated. Instead of exporting nothing but raw materials, it will be necessary to send them out in a manufactured state and the internal trade of the empire will have to be worked up with some semblance of the energy and perseverance which the Japanese have displayed in rendering themselves independent of foreign manufacturers. The difficulties are greatly enhanced by the inability of the Government to impose protective duties, and other means of assisting nascent industries will have to be devised.

Work of this kind, however, proceeds very slowly and it will be many years, if ever, before India can be justly ranked among the manufacturing countries of the world, and in the meantime more attention must be paid to the great work which has been going on all this century, that of rendering the work of the cultivator as far as possible independent of the variations of the seasons. By anicuts and canals we have practically made use of all the water in our great rivers which can be relied on to flow continuously through the cultivation season. By huge reservoirs or tanks many irregular sources of supply have been turned to account and nearly all the obvious sites for storing water on have been occupied. In the future, therefore, the work will be more difficult and more costly than it has been hitherto and it is hopeless to expect that the splendid financial results of the past will

be again repeated. Yet in the South of India, at any rate, much can be done to economize water by improving the means of distribution and preventing the ryots from using it with actually harmful extravagance. The whole question of what is technically known as the "duty of water" requires years of careful study and experiment, and it can hardly be doubted that the time has come when a special branch of the Public Works Department should be established for the scientific investigation of this and other problems peculiar to Indian engineering. The work that is going on now at Assouan on the river Nile where a huge dam is being constructed to store up part of the flood waters in a long narrow reservoir will probably be repeated on some of our Indian rivers and the investigation and designing of projects of this kind will call for the highest possible ingenuity and skill to render them at all feasible and within the limits of our financial resources.

In fact, the storage of water is likely to become the great Indian engineering problem and attention will doubtless be paid to that portion of the rainfall which is absorbed by the earth and disappears from sight, to find its way by deep and tortuous passages to the sea. Two and one-half million wells irrigating fully ten million acres of land attest the importance of the subterranean supplies of water and indicate that in this direction there are immense possibilities. Underground water has never in India, been studied properly by engineers or geologists and wells are sunk, in a happy-go-lucky manner to a haphazard depth. They are constructed with primitive appliances and at small cost. Expectations are not usually great and as they are generally realized the people are content. Some wells dry up in the hot weather, some wells always respond to the demands that are made upon them and nothing is really known about their capacity to supply water. A few elementary calculations

however will show that the quantity of water drawn from most wells is but an insignificant fraction of the stores that must be below and which are continuously passing away through permeable strata till they ultimately reach the sea. Where the average rainfall is 30 inches per annum we may assume that one-third of this sinks below the surface and that therefore each square mile of land receives 640,000 tons of water. If but one-half of this quantity could be extracted from the earth by pumping from wells it would yield a continuous supply of one cubic foot per second for 136 days, which, with economical use, would fully suffice for the irrigation of 250 acres. Twenty one mhotes and twenty one pairs of bullocks working steadily for eight hours a day would draw out this quantity of water from a depth of 20 feet. Now there are no data available as to the number of wells per square mile. In parts of such districts as Coimbatore they are very numerous and the total yield of water from them may exceed one cubic foot per second per square mile, but over the greater part of India nothing approaching this quantity is obtained. From such data as are available, I estimate that wells in India yield about 40,000 cubic feet per second, a very large quantity of water but equal to only one-thirty-fifth of a cubic foot per second from the 1,400,000 square miles of total superficial area. Over a great part of India the rainfall is more than 30 inches a year and we know nothing as to what becomes of the vast quantity of water which annually sinks into the earth. We know that in some districts there are many wells with a good supply of water, in others few wells and the yield very precarious. Sometimes the reason is obvious from the nature of the surface and the configuration of the ground but in most cases it is just the reverse and many wells have been sunk by engineers in what were considered likely spots and have turned out useless.

The great majority of wells in this Presidency range from 20 to 40 feet in depth. They therefore derive their supply of water, with the exception of such wells as actually tap underground springs, from an inverted conical mass of earth, the axis of which is the well and the vertex the water-level. Each well is the centre of a certain mass of earth which absorbs water from the surface percolation until it is saturated and any excess slowly moves along the lines of least resistance. The well alters the direction of these lines and some water flows into it, but the greater part of the water sinks vertically till it reaches impervious strata. The deeper the wells the greater is their action in deflecting the lines of sub-soil flow and in some cases there is no doubt that vigorous pumping after heavy rain would materially increase the volume of the cone influenced by the well. This of course is the time when wells are left alone and advantage is not taken of such opportunities to form lines of sub-soil flow towards the well.

Artesian wells have been carefully studied in many lands but wells of the types found in India have been neglected and we know practically very little about them. Isolated experiments will not teach us much owing to our inability to see what is going on inside the cone of influence round the well. The intelligent ryots of the country have probably a good deal of information about the behaviour of their own wells and of those belonging to their neighbours and skilful examination of villagers in well-irrigation districts might lead to the collection of some useful preliminary data which might serve as the starting point for further enquiries. Very few wells exist which are known to yield enough water to offer any inducement to employ mechanical arrangements for pumping water from them. It is easy to see why this is so. The depth of the well is limited by the fact that

the primitive methods of sinking in vogue among the ryots prevent them going more than a few feet below the hot weather level of the water. With an engine and pump to keep the well dry much greater depths might be attained and possibly the supply of water enormously increased.

It is generally considered that mechanical methods of pumping water for irrigation are too expensive to be employed and it is generally supposed that animal power is the only means available. Let us consider an imaginary case and then see how far the conditions are likely to be realized in practice. The well is a deep one and yields half a cubic foot per second, with a water-level about 40 feet below the ground. It is provided with an oil engine and a pump. The engine is only worked for 16 hours per day and therefore has to lift 250 gallons per minute throughout that period.

Allowing an efficiency of 40 per cent. for the gearing and centrifugal pump, the engine would have to develope $7\frac{1}{2}$ brake-horse-power and would consume one gallon of kerosine oil, costing 7 annas, per hour. The monthly expense which such an engine would entail may be taken as follows :

	Rs.
Fuel for 24 days at Rs. 7 per day ..	168
Wages for 2 drivers at Rs. 12 & 10 per month	22
Lubricating Oil, waste and stores ..	15
Interest and depreciation on capital outlay, cost of repairs etc. at 20 per cent per annum on Rs. 4000 ..	67
Rs.	272

Compare this with the cost of working with cattle. In the paper on "Water-Lifts" we obtained the result that to work a mhote for 8 hours a day required one pair of cattle worth Rs. 100 and that they would do effective work equivalent to one-third of a horse-power. In this case the oil engine developes $7\frac{1}{2}$ horse-power of which 40 per cent. is used effectively so that the work done by the engine in any given time is equal to that of 9 pairs of cattle but the engine works twice as many hours per day as do the cattle and is therefore equivalent to 18 pairs of cattle. The cost of keeping each pair of cattle was found to be Rs. 18 per month or for 18 pairs Rs. 324 per month. With the oil engine and pump therefore a saving of Rs. 52 per month can be effected and the cost of raising water diminished to the extent of 16 per cent. Till comparatively recently this was the best result that could be put forward in favour of mechanical methods of raising water but now it is possible to make out a much lower estimate of the cost of generating power with oil engines owing to the feasibility of using crude petroleum instead of kerosine oil. At the present time the former costs as. 3 per gallon in Madras as compared with as. 7 per gallon for kerosine oil, and from careful experiments on an $8\frac{1}{2}$ horse-power Hornsby-Ackroyd oil engine at the School of Arts it was found that 8 gallons of liquid fuel did as much work as 9 gallons of kerosine oil so that the reduction in cost of fuel is in the ratio of 24 to 63. Applying this to the estimate given above of the working expenses of the oil engine the cost of fuel is reduced from Rs. 168 to Rs. 66 per month and the entire cost of running the engine is reduced to Rs. 170 per month as compared with Rs. 324 for cattle. It can therefore be fairly claimed that by the use of oil engines and pumps the cost of raising water can be reduced to one-half the present rates.

It would be useless to follow up the comparison between the two methods of pumping any further. It is sufficiently demonstrated that the employment of oil engines for pumping water is a perfectly practical method and can be employed with advantage whenever the quantity of water to be dealt with amounts to half a cubic foot per second. The initial capital outlay is beyond the means of the ordinary ryot, but it is not beyond those of many land owners and if only sufficient interest could be aroused among them in the improvement of their estates the ultimate benefit to the country at large would be incalculable.

The two and one-half million wells in India represent a capital outlay not far short of forty crores of rupees and what is wanted almost as much as new wells is the systematic improvement of those already in existence. Many are probably far too shallow and others are too small and do not present a sufficient area for percolation. To jump holes from 10 to 30 feet in depth and a few inches in diameter at the bottom of some wells is not a very difficult matter and the value of the tube would probably be greatly enhanced if the rock at the bottom were loosened by the explosion of two or three small charges of dynamite. To run short adits in the hot weather from the bottoms of many wells is perfectly feasible and both methods if tried would yield results far in excess of the cost. Yet these things are not done because the ryots do not know of their value; and even if they did, they would regard them with suspicion as innovations to be classed with many other attempts, by Europeans, at agricultural improvements. These are suggestions which have been tried in other places with success but so little do we know about this subject that I put them forward with diffidence and simply with a view to drawing attention to the urgent necessity which now exists for a systematic attempt to in-

vestigate the conditions under which the stores of subterranean water exist.

The matter is one surrounded with difficulties and it is only by an intelligent co-operation of wealthy land-owners, who can afford to install engines and pumps for the irrigation of their lands or the cultivation of their gardens, with persons possessing a sufficient knowledge of engineering and geology that anything can be done. In this country we rely too much upon official efforts and too little is done by the enterprise of educated and enlightened private individuals. In England, the late Mr. G. J. Symonds enlisted the services of thousands of meteorological observers and established a system of recording data connected with rainfall in the British Isles which has proved of national importance. The agricultural experiments carried out on the Rothamsted farm by Sir John Lawes and Sir Henry Gilbert for more than half a century is another instance of private work which has done much to convert rule of thumb practice into a scientific procedure and farming all over the world has greatly benefited from their disinterested labours. Nothing of this kind has ever been attempted in India and I venture to think that the problems presented by well irrigation would be a fitting subject for investigation and one in which many workers might profitably engage themselves. I have endeavoured to show how little is really known and how much is left to chance and I cannot doubt that if the work were started and the areas under observation gradually enlarged it would result in additions to our knowledge which would prove of great benefit to the whole community.

WELL IRRIGATION.

In June 1900 I contributed a short article to this Review on the very important subject of "Underground Water-supply" in which I endeavoured to show that the information available regarding the ultimate disposal of the rainfall in India was very limited, and that consequently it was desirable to scientifically study the question with a view to utilizing a much larger proportion of the subterranean water for irrigation than is at present done. As a preliminary step it was obvious that more powerful and cheaper methods of lifting water than by water-lifts worked by cattle were essential and I showed that the oil engine when employed to pump from a well yielding on an average throughout the day half a cubic foot per second or 190 gallons per minute was considerably cheaper and more convenient than any form of water-lift worked by means of animal-power.

The importance of well irrigation was fully recognized by the Irrigation Commission and a large amount of evidence was tendered by many witnesses. The report of the Commission may be expected to contain practically a complete summary of all the information available and will serve as a starting point for further investigations. Funds have already been placed at the disposal of the Madras Government for experimental work in this direction and during the next few years there is no doubt that a serious effort will be made to render available for agriculture a very large quantity of the water which now runs to waste beneath the surface of the earth.

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* *Indian Review*, August 1902.

In the year 1900-01, there were in the Madras Presidency 615,520 wells from which water is drawn for irrigation and the area of cultivated land partially or entirely dependent upon them was 1,171,346 acres of first crop and 498,878 acres of second crop. Each well on the average supplied water to only 2 acres of land and naturally the question arises—Is full use made of the stores of water below the soil? In many cases, possibly in a numerical majority of the cases, there is little doubt that all the available supply is utilized but in what may perhaps be a comparatively insignificant minority of wells the available supply is enormously greater than the present demand and vast quantities of water remain unused. It must be within the personal knowledge of most people that there are wells which yield a good supply of water throughout the year and never dry up even in years of severe draught. Such wells should be examined and attempts should be made to pump them dry. Many wells are only made use of to the extent that tanks would be, if they were only provided with high level sluices through which the upper water in the tank, and that only, could pass through the bund into the irrigation channels. In the south of India well-sinking is a very primitive business and the better the supply of water, generally the shallower the well. A ryot wants a well and, having selected a spot which he thinks suitable, he sets to work and either sinks a hollow cylinder of brickwork into the ground till water in sufficient quantity to satisfy his expectations is reached, or he excavates a big rectangular hole in the disintegrated rock which forms the sub-soil and goes on deepening it till the inflow of water is greater than can be dealt with by the modest water-lifting appliances at his disposal. Year after year in the hot weather when the water level is low, he may increase the depth by adding to the number of mhotes on the well and in this way many valuable water-

yielding wells have been sunk. Let us suppose however that the unwatering of the well in the hot weather is accomplished by a powerful engine and pump, the work of excavating will be easy and the depth may be rapidly increased till either the inflow is greater than can be dealt with or practical considerations clearly indicate that it is not worth while to go any deeper. For water to flow into a well the level in the well must be lower than in the sub-soil and the greater the difference in level the greater is the force tending to make the water flow into the well. But the lower the level in the well the greater is the amount of work which has to be done to raise the water above the surface and ryots prefer numerous shallow wells to a few deep ones. The number of cattle employed in lifting water is enormous and it is improbable that any great extension of well cultivation can take place under the present system for lack of animal power to do the necessary work of extracting the water. A ryot must have cattle and while the crops are growing they can be profitably employed in raising water, but directly he has to keep cattle specially for the purpose, well irrigation becomes expensive and unprofitable. A pair of good serviceable bullocks in constant work cannot be kept for less than Rs. 18 per month including the wages of a driver and the work they do can be far more cheaply performed by a good oil engine or steam engine. But these machines, even when of the smallest size practicable, are far too big for the work of drawing water from ordinary wells and they can only be employed when the conditions are unusual in respect to the volume of water to be obtained from a well. A $3\frac{1}{2}$ horse-power oil engine, which is the smallest size it is advisable to employ, can be worked for 16 hours a day at a cost of $2\frac{1}{2}$ rupees and will do as much work in lifting water as 8 pairs of good bullocks costing Rs. 144 a month.

Allowing for repairs, depreciation and interest I have no hesitation in stating that the cost of pumping by an oil engine of this size, driving a centrifugal pump, is almost exactly one-half what it is when bullocks are used, provided only that there is sufficient work to keep the engine fully employed.

Before developing further the idea of employing oil engines for well irrigation I propose to briefly describe an experiment now in progress. About 6 miles from Chingleput is a small pariah settlement founded by Mr. Andrew of the Free Church of Scotland Mission. About 50 acres of land are under cultivation and the crops are watered by 5 wells which have been sunk since the settlement was started about eight years ago. Greatly interested in the question of well irrigation Mr. Andrew offered to allow me to conduct experiments on his wells and with the assistance of funds placed at my disposal by the Madras Government, at the instance of the Chief Engineer for Irrigation, Colonel Smart, R.E., I have been able to put to the test of practical working the idea of using oil engines. I selected what was supposed to be the best well on the settlement and at the beginning of March I tried to unwater it by working a Persian wheel continuously night and day by means of relays of bullocks. I soon found it desirable to increase the pumping power and accordingly a picottah was set up and worked by gangs of coolies night and day. The draught on the well amounted to about 2,500 gallons per hour or allowing for irregularities to between fifty and sixty thousand gallons per day. This resulted in a gradual lowering of the water-level till the depression amounted to 5½ feet, when the level became stationary and the inflow was equal to the amount withdrawn. Arrangements were then made with Messrs. Massey & Co. of Madras to supply a 3½ horse-power Hornsby-Ackroyd oil engine and a 3-inch centrifugal pump, the

combination being capable of lifting 170 gallons of water per minute to a height of 30 feet. Pumping was started at the end of March and in a few hours the well was emptied. An attempt was then made to deepen the well and a central hole 15 feet in diameter was sunk 7 feet when hard rock was met with. To increase the area through which percolation could take place adits were run horizontally from the bottom of the well through the partially disintegrated rock. Four were started, but two of them had to be given up before they had been run out 10 feet on account of boulders, the other two were carried outwards about 25 feet and 20 feet respectively, and the percolation through their sides forms the main source of inflow to the well. The cost of the adits was Re. 1 per foot run,and they were stopped as soon as the rate for excavating them rose above that amount. The result of the operations was to increase the inflow from 40 to 66 gallons per minute or from 60,000 to nearly 100,000 gallons per day. Pumping has continued all through the hot weather and the inflow has somewhat decreased. On the 20th July it was measured and found to be about 67,000 gallons per day. With the advent of the rains it is expected that the inflow will materially increase but how much is quite uncertain. At present the engine runs nine hours a day,in three periods of from two to three hours each. When pumping ceases, the flow of water accumulates in the well and at the beginning of each working interval there is about 5 feet of water to be removed. The average lift is 25 feet and the engine consumes about 2 gallons of oil per day costing as. 12. The wages of the driver are Rs. 12 per month, so that the total cost of running the engine including the cost of stores amounts to only Rs. 40 per month. Later on with longer running hours it may amount to Rs. 60 per month and for this sum 50 acres of dry cultivation will be fully supplied with water. The capital outlay

on the engine and pump and the cost of fixing the same amounted to Rs. 2,500 and an allowance of Rs. 40 per month for interest, repairs and depreciation will be a very liberal provision, making the total monthly charges Rs. 100 when running and about Rs 50 when standing. Assuming that water is required for eight months in the year, the total cost of this engine and pump will be Rs. 1,000 per annum. For this sum 50 acres of dry crop will be watered and I am inclined to think that possibly, with the supply of water to be expected, the area may be much larger but only a continuance of the experiment over several years will enable this to be definitely determined. The conditions under which this experiment is being conducted are by no means favourable and much better results could be obtained in many places. The well yields a fair supply of water, but there are undoubtedly very many which would give double the supply. The engine and pump worked to their maximum capacity would raise 250,000 gallons a day to a height of 30 feet, or nearly half a cubic foot per second, sufficient for from 100 to 125 acres of dry cultivation. Under such circumstances, the cost of supplying water to the land would not amount to more than Rs. 12 per acre per annum. This is a result so very satisfactory that when it becomes known and fully realized it ought to lead to an immense employment of these modern methods of lifting water.

It is well known to engineers that the cost of generating a unit of power rapidly decreases as the amount of power generated by a single engine increases. In view, therefore, of the fact that the great majority of wells are unable to yield sufficient water to give adequate employment to even the smallest engines, it has occurred to me that possibly large tracts of land could be supplied with water from wells by electrically driven centrifugal pumps, the power being generated at a central station and distributed by

a net work of overhead conductors. From an engineering point of view the problem is a comparatively simple one and its practicability simply depends upon the cost of the installation both as regards capital outlay and working expenses. I have therefore obtained estimates of the cost of the machinery from well-known firms in England and with the information thus obtained I have worked out two imaginary schemes assuming conditions that could be realized in many places in this Presidency. The first scheme is a comparatively small one for the irrigation of five or six hundred acres. All the land is assumed to be situated within a rectangle 2 miles long and 1 mile wide. The water-supply is derived from twelve wells scattered over the area. Each well may be assumed to cost Rs. 500 though under favourable conditions, they would not cost more than half this amount as the depth is not to exceed 35 feet. The water would be lifted by a 3″ centrifugal pump driven by a direct coupled 3½ horse-power electromotor, the pump and motor complete and fixed in the well costing Rs. 750. The current would be supplied from a generating station situated near the centre of the area and 5 miles of overhead conductors costing about Rs. 650 per mile, would be required for distributing the energy. The generating station might be supplied with a steam engine and boiler costing Rs. 4,000 or with an oil engine, in which liquid fuel could be used, of the same power costing Rs. 3,600, driving a dynamo costing Rs. 1,800 which would give out a current of 27 ampéres at 550 volts pressure equivalent to 20 electrical horse-power and capable of driving 4 of the pumps under full load, or 5 under the average load which would come upon them. Each pump would discharge 150 gallons per minute, so that with 5 pumps going the supply of water would be 2 cubic feet per second or sufficient for 500 acres of land. The method of working would be to run a motor till the well was

emptied and then shut off the current and allow it to fill up by percolation, whilst the current was employed in driving another motor in another well. With 5 motors running out of 12, water would be drawn from each well an average of 10 hours per day. Including all items, the total cost of the installation would be as follows:—

	Rs.
Engine house	4,000
Engine and dynamo	5,400
Switch board, etc.	500
12 Wells at 500/	6,000
12 Pumps and motors at 750/ ..	9,000
5 Miles of line at 650/ per mile ..	3,250
Contingencies 10 %	2,850
Total ..	31,000

The working expenses would be as follows:—

	Rs.
Repairs, interest and depreciation at 12½ % ..	3,875
Liquid fuel at As. 3 per gallon at 2 gallons per hour for 5,000 hours	1,875
Superintendence and labour Rs. 130 per mensem for 12 months	1,560
Miscellaneous stores	200
Total ..	7,510

That is the cost of watering 500 acres of land would amount to Rs. 15 per acre per annum, the land being under cultivation practically the whole time. This is far too high a charge for

ordinary wet crops, but it is by no means excessive for garden cultivation, such as is practised in agriculturally advanced districts like Coimbatore. For projects of this kind to pay, it naturally follows that when all the resources of modern engineering are devoted to the problem of supplying water and a considerable outlay in machinery and plant is involved, the agricultural operations must be of a similar character and the cultivators must be prepared to put capital and labour into their fields to obtain the best possible results. The selection and rotation of crops must be judicious, the lands must be well manured and in general terms what is known as *intense* cultivation must be practised.

Let us now consider the possibilities of operating on a much larger scale and for this purpose we will assume that there is a strip of land about 10 miles long and from one to two miles wide lying alongside a river channel. Such a piece of country actually exists on the Pálàr not far from Chingleput. The land near the river will probably be at a slightly higher level than further away and as the wells will draw their water-supply mainly from the subterranean flow of the river they will all be situated near the river bank. The wells will be sunk near the river bank at an average distance apart of one-fourth of a mile. In all, there will be 40 such wells and the power station will be situated in the middle, with 20 wells on either side, the most distant well being $4\frac{7}{8}$ miles off. Assuming that the average inflow into each well is half a cubic foot per second and that the average lift is 30 feet the total actual work which will have to be done by the pumps will be 68 horse-power. To determine the power required at the generating station, we may make the following assumptions regarding the efficiency of each part of the system of power distribution :—

Efficiency of dynamo	90 per cent.
Efficiency of transmission	90 per cent.
Do. motor	80 "
Do. pump	45 "

Combined efficiency of whole system 30 per cent. so that the engines will have to furnish 227 horse-power. The following estimate of the cost of the plant may be taken as approximately accurate :—

	Rs.
Engines	45,000
Dynamo	9,000
Engine house	7,500
Switch board and fittings	2,000
40 wells at Rs. 500 each	20,000
40 motors and pumps at Rs. 750 each ..	30,000
Overhead conductors 10 miles at Rs. 1,500 a Mile	15,000
Contingencies, 10 per cent.	13,700
Total ..	1,42,200

The working expenses on an assumed running of 5,000 hours per annum would be :—

	Rs.
Fuel for engines	11,250
Superintendence and labour	3,600
Repairs, interest and depreciation at 12½ per cent.	17,775
Miscellaneous stores	1,000
Total	33,625

The area that could be irrigated would be between four and five thousand acres and the annual charge for pumping would amount to not more than Rs. 8 per acre. The case considered is perhaps a favourable one, but without doubt a careful examination of the country would reveal many such, and it is eminently desirable that advantage should be taken of the natural facilities where such exist.

So far we have only considered the question of well irrigation when the power is supplied by oil or liquid fuel engines, but it is open to us to go one step further and consider what use can be made of water-power which in certain districts is available in vast quantities throughout the greater part of the year. Without going into details, one or two general facts may be noted which tend to show that there is a wide field open to engineers in India in utilizing the power of water falls to lift water from wells over very extended areas. For industrial operations a continuous supply of water all the year through is generally essential, and expensive storage works have to be constructed to tide over the period of scarcity of water during the hot months of the year. When the water-power is to be used for pumping water from wells the failure of the supply of power during the hot weather is of little or no importance as the cultivation can be so arranged that the land requires no water at that season. Water-power can therefore be provided at much less expense for such schemes as we are now discussing, and if it be a profitable undertaking to generate power at the Cauvery falls and carry it over 90 miles to the Kolar mines, under onerous conditions regarding failure of the supply, it is obvious that it will be still more profitable to utilize water-power under the much less exacting conditions which would prevail in irrigation pumping.

The report of the committee on utilization of water-power at Periyar stated that electric energy could be delivered in Madura 80 miles away for Rs. 22–8–0 per horse-power per annum and in Madras for double that sum or Rs. 45. It is more than doubtful however if this result could under any circumstances be attained and it would be safer to assume that the actual cost would be about three times as much but even then it would appear to be practicable to lift water from wells or rivers by the agency of electrically transmitted energy over the greater part of the South of India. The minimum power available at the Periyár during ten months of the year is officially stated to be 30,000 horse-power and there is reason to suppose that the efficiency of the whole system of generation, transmission and utilization would be one fourth; so that 7500 horse-power would be the work actually accounted for by the water lifted. On an average lift of 40 feet this would be equivalent to 1,650 cubic feet per second or sufficient for 412,500 acres of land. At Rs. 10 per acre for annual charges this would amount to 41¼ lakhs and would permit of a capital expenditure of at least 3 crores of rupees, probably a much larger sum than would actually be needed.

I have drawn attention to the possibilities attendant on the utilization of water-power for pumping purposes because ultimately I think they will be realized on an exceedingly big scale, but that day is yet distant and the business of immediate practical importance is the smaller schemes which I have outlined in this note. They involve but small expenditure, each one started and proving successful adds to the store of information we must gather about underground water and places us in a position to ensure that in subsequent undertakings the risk of failure will be a constantly diminishing quantity. The exceeding simplicity of working, characteristic of good oil engines and their remarkable

economy in the matter of fuel has changed the conditions under which water-lifting can be undertaken. It is necessary to reconsider the position and demonstrate by practical working that the primitive appliances of the ryot can be superseded by methods of water-lifting so greatly superior as to open out entirely new possibilities regarding the utilization of subterranean water.

THE COST OF POWER.

Engineers are beginning to recognize the fact that after a century of development the steam-engine has been brought to the highest degree of perfection that is attainable, and to confess in despair that now, even under the most favourable conditions, it is a very imperfect machine for converting heat generated by the combustion of fuel into work. The efficiency of a heat-engine depends upon the temperature with which the working fluid enters the engine and the temperature at which it is ejected. In the case of the steam-engine the range is comparatively small and at the outside does not amount to more than 300°F. under which conditions the theoretical efficiency of a perfect heat engine cannot be more than 33 per cent. and in practice not more than 20 per cent. has been actually realised. The vast majority of small steam-engines do not attain more than a fraction of even this meagre degree of success and we shall probably be right in stating that the average thermal efficiency of engines in this country excluding a few large condensing mill engines is under 5 per cent. That is to say that of the heat generated by the burning of 10 lbs. of coal in the boilers which supply steam, we obtain less than the equivalent energy of one-half of a pound of coal in the effective work done by our steam-engines. This extremely unsatisfactory result has long engaged the attention of Physicists and Engineers and enormous sums of money have been expended in endeavouring to obtain some process of converting heat into work which will

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yield more favourable results. The introduction of the gas-engine with its immensely greater range of temperature in the working, cylinder, about 30 years ago marked the commencement of a new era in our methods of obtaining power and in the case of small engines remarkably good results were soon obtained, but for a long time the difficulties connected with the working of large gas-engines seemed insuperable. Within the last few years, however, they have been overcome and at the present time there seems to be no practical limit to the size of gas-engines. In a paper read before the British Association at Belfast Mr. H. A. Humphrey stated—"The development of gas-engines which has taken place during the last few years has but few parallels in the history of engineering enterprise. Gas-engines of 1,200 H. P. and 1,500 H. P. are already working and others of 2,000 H. P. to 4,000 H. P. are being constructed. In the Paris Exhibition of 1900, a 600 H. P. Cockerill gas-engine created much surprise, but now the makers have in hand an engine of 2,500 H. P. and are quite prepared to build a 5,000 H. P. gas-engine." The main secret of the success which has been obtained, is improved mechanical construction, the provision of efficient arrangements for keeping the working parts cool and the adoption of much higher pressures at the end of the compression stroke in the cylinder whereby the use of a very much poorer quality of gas is possible. The waste gases escaping from blast furnaces have been found admirably adapted for producing power in large gas-engines and as much as 1,000 H. P. can be obtained from every ton of coke that is consumed per hour in the manufacture of iron in blast furnaces, so that there is no doubt that the combination of a blast furnace and a gas-engine is the most efficient thermal process which has yet been devised. There are many processes suitable for the manufacture of gas of a poor quality in large quantities which can with advantage be used

in large gas-engines but of these we need only mention one, the results of which are remarkably promising. Dr. Ludwig Mond of the great Cheshire Chemical Works owned by Messrs. Brunner, Mond and Company has devised a process of manufacturing producer gas which from bituminous coal yields from 140,000 to 160,000 cubic feet of gas per ton of fuel fed into the producer and at the same time recovers as much as 90 lbs. of sulphate of ammonia, the value of which is about Rs. 160 per ton. Using this gas, one H. P. hour per pound of fuel can be obtained,—a result which is much superior to that obtained in the largest and best type of steam engine.

Concurrently with the development of the gas engine as one form of internal combustion engine, we have to record the progress made along parallel lines by a similar type of engine in which kerosine oil or crude petroleum is used. In the latest form of oil-engine one H. P. hour can be obtained from 0.75 lbs. of kerosine oil, but kerosine oil costs Rs. 90/- a ton and the oil-engine can only successfully compete against the steam engine when the power required is small and then the steam-engine is notoriously at a disadvantage. Crude petroleum can however be obtained at about Rs. 30 per ton in Madras and the efforts which have been made to utilise this liquid fuel in internal combustion engines have resulted in no small measure of success. By slight modifications in their construction, most forms of oil-engine will work with liquid fuel, and engines of small size can be obtained which do not consume more than one pound of liquid fuel per hour. Excellent as this result may be, it is entirely put into the shade by an oil-engine of German origin, known as the Diesel oil-engine, which consumes as little as 0·41 pounds of crude petroleum per H. P. indicating that the thermal efficiency is well over 30 per cent. or about the same

value as the maximum thermal efficiency of a perfect steam engine.

This very brief summary of recent progress in methods of developing power is put forward in the hope of drawing attention in India to the subject. Our resources are so limited that we cannot afford to waste them and the users of power, whether in small or large quantities, must keep abreast of modern progress in this direction if they wish to successfully face the competition of progressive countries. Where water-power can be obtained the cost of production is generally much lower than by any of the means we have hitherto mentioned; but unfortunately in this country it is only available in places where it is of no use and to convey it by electricity to any distant point is only feasible on a scale which, with one single exception, is at present far beyond industrial needs of the country. There are a few instances such as those at Gokak and Ambasamudram where water-power has been successfully used to drive cotton mills but the only case of the generation of a large amount of power and its successful transmission over a long distance is that which has recently been carried out in the Mysore Province.

The successful completion of the Cauvery Falls Power Scheme has naturally attracted a large amount of attention in India, not only because it is the first work of its kind that has been carried out in this country, but also because of the extremely satisfactory financial results that are expected to attend its operation. The circumstances were unique and are not likely to repeat themselves, so that the bare statement of the facts of the case does not afford much information that is likely to be of use elsewhere and it is necessary to carefully examine the details of the scheme and eliminate from it all the exceptional items before we can obtain data which may prove of use in the

consideration of other projects for the development of large amounts of power.

The scheme, as carried out, provided for the generation of sufficient power at the Falls to yield 4,000 H. P. at the Kolar gold field, distant by the transmission line 93 miles. For the power that is being made use of, the Cauvery Falls offer good facilities for its production at a moderate capital outlay. The supply of water may be regarded as reasonably certain all the year round, the fall is a very convenient height and the hydraulic works presented no features necessitating excessive expenditure on their construction. The transmission line is a long one but this is to a large extent compensated for by the compactness of the distributory works, where the power is employed in comparatively large units and in most instances continuously night and day. All things considered, these works may be regarded as a favourable instance of the utilization of water power. In round figures the expenditure has been £300,000 or forty five lakhs of rupees, equivalent to a capital outlay of £ 75 or Rs. 1,125 per horse-power available.

At the present time the total amount of power generated, at the Kolar mines is probably not far short of 10,000 horse-power and careful calculations showed that the annual cost to the mines was over £30 or Rs. 450 per horse-power per annum. This expenditure on power is undoubtedly very heavy and is largely due to the gradual growth of the demand for power and the utter impossibility, during the opening up of the mines, of making provision for subsequent requirements. As we shall see later on it would now be possible to provide 10,000 horse-power for a very much smaller annual charge than has been, and in fact still is paid. The agreement between the Mysore Government and the General Managers of the mines provides for the very early

recoupment of the capital expenditure as the life of the mines is a somewhat uncertain quantity. During the 1st year, the charge per horse-power is to be £ 29, during the next 3 years, £ 18, during the fifth year £ 24 and for all subsequent years £ 10. The returns to the Mysore Government in 5 years will be £ 380,000 on a capital outlay of £ 300,000 and after that they will receive practicallay 10 per cent. on their investment. On the other hand the mines, without incurring any outlay, will after the first year, save £ 50,000 a year except during the fifth year when they will have to pay an extra rate which will reduce the saving to £ 26.000. In the sixth and following years they will save as much as £ 80,000 a year on the present rates for power. For both parties the results are magnificent and it would be difficult to overestimate the credit due to those who have conceived and carried to a successful issue a scheme possessing so many novel features in Indian engineering and holding out promise of such exceptional financial results.

Having thus briefly examined the Cauvery Power Scheme as it is actually working let us now eliminate all the special features due to its connection with mining ventures of uncertain duration. We may assume that such a scheme would cost what it approximately actually did cost *viz.*, £ 300,000 and that the expenditure has been divided under the following heads.

Hydraulic works	..	£ 65,000
Turbines etc.	..	35,000
Generating station	..	40,000
Transmission line	..	9,500
Distributing plant	..	65,000
	Total	£ 300,000

The working expenses may be estimated as follows:

Rental for water power @ 10/-per H. P. per annum		£ 2,000
Interest on capital @ 5%	..	15,000
Working expenses	..	6,000
Sinking fund for Machinery @ 7½ % on £ 110,000	..	8,250
Sinking fund for other works @ 1½% on £ 190,000		2,850
Total	..	£ 34,100

Of the above items the most difficult to estimate is that due to depreciation, probably, if anything, the rates allowed are excessive but a liberal allowance of contingencies is necessary. Out of date electrical machinery is only worth scrap heap prices and it would be somewhat rash to assume that within the next twenty years there will be no material improvement effected on a three phase transmission plant working at 30,000 volts. Accepting the above figures we obtain the result that to generate one horse power continuously costs £8-10-0 per annum. Under extremely favourable circumstances as for instance with a short transmission line it might not amount to more than £ 6, and under less favourable conditions say with a transmission line 200 miles in length it might amount to £10. These figures are much higher than the estimates generally framed regarding the cost of utilizing water power but as the data they are based upon are taken from actual results they are less open to criticism and moreover they do provide for an adequate return to every interest involved which is not always the case with projects which have been carried out in the past in other countries.

The average cost of one horse-power per annum at the mines is authoritatively stated to be fully £30 and the reason for this excessive charge has been briefly alluded to. The engines

which generate this power are scattered all over the field, some are large, some are small, but in almost every case the conditions under which they work are not favourable to fuel economy. The bulk of the power is absorbed in driving the mills, working air compressors and in the winding engines which work the hoists at each shaft. The success of the Cauvery Electrical Scheme demonstrates the possibility of generating all the power in a central station and distributing it to the places where it is wanted by electricity. The question is what would such a scheme cost and at what rate could power be supplied.

Practically there are available two sources of fuel supply, (1) coal from Bengal or Singareni costing about Rs. 20 per ton and possessing a calorific value of rather less than four-fifths that of good Welsh coal, (2) Liquid fuel imported from Borneo by the Shell Transport and trading Company, costing, about Rs. 36 per ton and of a calorific value 70 per cent. greater than that of country coal. The coal must be burned in boilers, and its energy converted into work by the agency of steam, but the liquid fuel can either be burned as coal or used in a suitable form of internal combustion engine. With the best type of steam engine the consumption of fuel in boilers may be taken as 2 lbs. of country coal per horse-power per hour or $1\frac{1}{4}$ lbs. of liquid fuel so that the cost of power is not materially different whichever of these fuels be employed. But if the liquid fuel be used in an oil-engine the consumption varies from 0·80 lbs.in an engine of the Hornsby-Ackroyd type to as low as 0·41 lbs. in the latest form of Diesel engine. Obviously the extremely remarkable economy of the latter type of engine presumes for it a great future and we propose to compare the cost of supplying 10,000 horse-power from a central station by means of alternators driven by (1) Steam engines and the country coal and (2) Diesel oil engines and liquid

fuel. To allow for losses of energy in the alternators, transmission line and motors we shall assume that 100 brake horse-power at the engine will give 66⅔ brake horse-power at the motors and therefore to obtain 10,000 horse-power at the motors it will be necessary to generate 15,000 horse-power at the engines. As the engines will have to run day and night it will be desirable to provide ⅓ more power than will be actually required to allow each engine to be shut down for examination or repairs. The central station would therefore be provided with twenty, 1,000 horse-power engines and an equal number of alternators. Whether steam-engines and boilers be used or Diesel oil-engines the capital expenditure will not be materially different. The preparation of detailed estimates of the cost of either of these two installations is a work of some magnitude and could only be properly done after extensive enquiries among machinery makers all over the world. Instead of doing this, I have carefully examined the expenditure on a number of large power stations in England and have gone through the estimates for the work which has already been done in Mysore and as a result I have come to the conclusion that to carry out this scheme in its entirety would cost about £ 500,000 or £50 per horse-power, just two thirds the rate of the capital expenditure already incurred to supply the Gold fields with power. Now as to the annual working expenses, the main item would be the cost of fuel. Assuming that 2 lbs. of coal or 0.41 lbs. of liquid fuel is consumed for each brake horse-power hour of the engines, the quantity of coal required per annum would be 116,000 tons which at Rs. 20 per ton would cost Rs. 23,20,000 whilst of liquid fuel the quantity would be 24,360 tons costing at Rs. 36 per ton Rs. 8,76,960. Stores of various kinds would cost about one lakh per annum and the expenses for superintendence, labour and

management would fall within 2½ lackhs, so that the working expenses of the scheme would be

By steam power about

Rs. 27,00,000 or .. £ 180,000

liquid fuel engines

Rs. 12,50,000 .. £ 83,400

To these charges we must add interest on capital at 5% and a sufficient charge to form a sinking fund to extinguish the capital expenditure in a reasonable time. The life of the mines is an uncertain quantity but to assume that they will last another 15 years is not a very sanguine estimate and if the interest on the sinking fund be taken at 5% the annual charge on a capital outlay of £ 500,000 will be £ 25,000 a year.

The total cost of 10,000 horse-power then works out as follows:

	Steam	Liquid Fuel
Working expenses	£ 180,000	£ 83,400
Interest on capital	25,000	25,000
Sinking fund	25,000	25,000
Total	£230,000	£133,400

That is to say the charge now estimated at over £30 per horse-power would be reduced to £23 in the one case and £13-10-0 in the other, and an annual saving in working expenses would be effected of £ 70,000 or £ 166,600 according as the old or the new methods of generating power were adopted. These rates cannot of course compare with those which the mines will u timately pay for the water power of the Cauvery falls, but the quantity of that power is limited if a continuous supply is essential. Possibly the Falls may be able to yield another 4,000 H. P. continuously, but that is the maximum that can be

obtained without expensive storage works. It would therefore seem that there is ample room on the mines for some such project as has just been outlined and there is no doubt that if advantage is taken of the recent rapid progress that has been made in the development of the internal combustion engine a very material economy can be effected in the working of the mines.

The Kolar mines are an instance of a large amount of power being required in a place where coal and liquid fuel can compete with one another on approximately equal terms but there are many places where the price of coal is so low that it possesses an immense advantage over liquid fuel as an heating agent. We have seen that the Diesel oil-engines use but slightly over $\frac{1}{5}$ the weight of liquid fuel that the best steam-engines require of Indian coal but we can place coal on much more equal terms with liquid fuel if we abandon the steam engine and first of all convert our coal into producer gas and then use this producer gas in a gas engine. In this way we can obtain 1 brake horse-power from 1 lb. of coal and although this doubling of the efficiency of coal as a source of power would still leave to liquid fuel the premier position at Kolar on account of the high cost of coal, yet in Calcutta where liquid fuel cost from $3\frac{1}{2}$ to 4 times as much as coal the position is reversed. There the marvellously economical Diesel oil-engine would use about $\frac{1}{3}$rd the weight of fuel that would be consumed by a producer gas plant but the fuel costs 4 times as much and hence in Bengal, and in every other place where coal is equally cheap, no form of engine can compete with the large gas engine working on producer gas.

So far as can be foreseen after a century of continuous improvement the steam engine has reached its ultimate limit of development and already it has been hopelessly beaten by the internal combustion engine, a product of the last 30 years. For

the generation of large amounts of power the day of the steam-engine should have passed but that it has certainly not so vanished is simply due to its immense prestige and to the reluctance of engineers to commit their clients to a large expenditure on machinery which is still in a transition stage and which still has to earn a reputation for endurance and reliability which can only be acquired in course of years. Where fuel is cheap there power is most largely generated, and as the cost of the fuel is but one item in the working costs of an installation, whether it be a mill, a central power station or an electric light plant, consequently engineers are slow to risk their reputations on new ideas with which they have no personal experience. Hence the steam-engine flourishes and will probably long continue to flourish.

Except in the neighbourhood of the mining districts coal is by no means a cheap commodity in India and a poor country can only hope to improve its material position by utilizing its resources in the most economical way possible. Of mechanical power we make little use outside a few big mills and factories. Industrial undertakings are few and scattered over wide areas so that the advantages which can be obtained from concentration in a limited area are entirely lost. Central power stations are an impossibility and each little user of engine power works his small plant at great expense. A small steam engine is very wasteful of fuel yet it is almost invariably employed.

The advantages of small oil engines are however beginning to be appreciated and it is certain that their use will rapidly extend when the fact is realized that those of the Hornsby-Ackroyd type can be run equally well with either kerosine oil or liquid fuel. The former costs at the present time Rs. 122-8-0 per ton, whilst the latter is only Rs. 45 per ton in Madras and would be but Rs. 30 a ton if the consumption were on a sufficiently large

scale to justify the importing of it in bulk oil steamers direct from the oil districts. For intermittent running the economy effected by generating power with kerosine oil is considerable, but for steady work all day it is only in places where coal or wood is expensive and oil fairly cheap that the latter can be used with advantage. With liquid fuel however the oil engine becomes a very economical motor and the following figures obtained from the School of Arts Madras may be of interest. The engine there used is an 8½ B. H. P. Hornsby-Ackroyd and was run for several years with kerosine oil. Liquid fuel is now used and the engine runs for 9 hours a day on an average consumption of 8 gallons of liquid fuel, which costs as. 3 per gallon delivered at the engine shed. The average B. H. P. of the engine is probably over 7 as the load is fairly constant and practically as much as the engine can do. Taking it at 64 B. H. P. hours per day the cost of running amounts to

Liquid fuel	1	8	0
Wages	0	8	0
Interest, depreciation and repairs at 12½ % per-annum on Rs. 3,000 allowing 300 working days.	1	4	0
Lubricating oil and stores	0	8	0
	3	12	0

Practically this is equal to 11 pies per brake horse-power hour. At the Gun Carriage Factory Madras there is a similar oil engine but much larger and capable of developing over 40 B. H. P. From information kindly supplied to me by Major C. C. Townsend R.A., the superintendent, it appears that the engine is heavily loaded and during the working day of 7½ hours probably an average of more than 40 B. H. P. is developed as the indicative diagrams show that as much as 55 H. P. is developed

in the cylinder. The consumption of kerosine oil was 34 gallons per day and that of liquid fuel is now 30 gallons per day. Taking the average B. H. P as 40 and the working day as $7\frac{1}{2}$ hours, 300 B. H. P. hours are obtained from 30 gallons of fuel or 10 B. H. P. hours per gallon.

The cost of power in this case may be estimated as follows:

30 gallons of fuel at as. 3 per gallon	5	10	0
Wages	1	8	0
Interest, depreciation and repairs on Rs. 8,000 for $12\frac{1}{2}$ per cent. allowing 300 working days...	3	5	4
Lubricating Oil, Stores etc.	1	0	0
Total ..	11	7	4

Or $7\frac{1}{3}$ pies per brake horse power hour.

In the paper on Water Lifts the conclusion arrived at was that, under favourable circumstances, animal power would yield $\frac{1}{3}$ H. P. for 8 hours per day or $2\frac{2}{3}$ H. P. hours per day for an expenditure of Rs. 18 per month. The 64 H. P. hours obtained with the School of Arts engine, if supplied by animal power, would cost $24 \times 18 = 432$ rupees per month whilst actually it costs Rs. 93-12-0 or less than one fourth. For agricultural operations a pair of bullocks is an inconveniently small unit of power and the smallest size of oil engine is somewhat too large for the existing methods of culture; but for lifting water-driving oil mills or sugar cane mills it should be possible to gradually introduce co-operation among ryots and land holders to secure to themselves the benefits of cheap power. For lifting water the oil engine possesses the advantage that if necessary it can be run almost continuously but it is unfortunate that the centrifugal pumps which are the only convenient means of applying that power are so inefficient that their

efficiency falls below 50 per cent. and often below 40 per cent. In consequence, the enormous superiority of the oil engine is in part lost and there is nothing that would prove of greater benefit to Indian agriculture than the introduction of an improved centrifugal pump with a much greater efficiency.

THE VALUE OF WIND-MILLS IN INDIA.

Previous to the advent of the steam-engine the wind-mill was held in high repute as a means of obtaining motive power, and it was largely used for grinding corn and for raising water for the drainage of low lands. The old-fashioned mill was cumbrous and expensive, and, as a rule, it was so heavily loaded that it only worked in strong winds. The disadvantages attendant on its use were many and serious and it is not surprising that it fell into disrepute. Subsequently the invention of the dynamo and the electrical accumulator again drew the attention of Engineers to the wind as a source of energy and the modern aermotor or wind-engine was gradually developed. The expectations based upon the conversion of the power of wind into electrical energy and its storage in accumulators have not been realized mainly because of the large capital outlay involved in the plant. But a very large field for the use of wind-engines has been found in employing them to pump water either for domestic purposes, for drainage or for irrigation, and at the present day many thousands are doing useful work in these directions. In no part of the world is there more scope for them than in India where millions of cattle are daily employed in raising water from wells for the irrigation of land but unfortunately they are too expensive for the individual ryot and there is a generally prevalent idea that the wind-currents in India are too light to make the amount of energy derivable from them of any material value.

About two years ago I was asked by the Board of Revenue to furnish them with information regarding the utility of wind-

mills for irrigation work, and, as there was no trustworthy information available, I proposed to Messrs. Parry & Co., the Madras Agents of the Chicago Aermotor Company, that, if they would place an aermotor at my disposal for purely experimental work, I would undertake to collect and place on record the observations. After consultation with their principals in America, it was settled that a 16 ft. aermotor mounted on a 70 ft. tower should be handed over to me to experiment with and the Board of Revenue agreed to furnish the necessary funds.

A new aermotor was accordingly sent out, and I had it put up in the compound of the School of Arts, Madras. An attempt was made to sink a well, but the sub-soil proved so unsatisfactory that the well was abandoned and a masonry tank 10 ft. square and 5 ft. deep was constructed under the aermotor tower. It was originally intended that the aermotor should drive a rocking lever at the ground level, to which lever two pumps rods were to be attached, one working an 8″ pump, the other a 6″ pump, both to be fixed 25 ft. below ground level in the well. But when the well had to be given up it was found impracticable to arrange for driving two pumps except at a greater expense than was warranted and only the 8″ pump was fixed in the tank.

The object of the experiment was to ascertain the quantity of water which the wind-mill would lift to a certain height every day in the year, and as there was no necessity to use the water for any purpose it was decided that the pump should be arranged to lift the water 25 ft. and allow it to fall back into the tank. To obtain the information required, a tacheometer was fitted to the pump to record every stroke, and to obtain the quantities of water lifted, it was only necessary to ascertain, as accurately as possible, the delivery of water per stroke. To do this, another tank 10 ft. square and 5 ft. deep was built above the level of the

ground and the water discharged from the delivery pipe was carried to it by a two-inch main fitted to the bottom of a wooden funnel into which the water lifted by the pump was discharged.

The aermotor and tower were bolted together horizontally on the ground and were then lifted into a vertical position by means of a derrick. The plan followed was the very ingenious one devised by the Aermotor Company, but it gave us a great deal of trouble, as the tower, though it has proved to be amply strong enough in the erect position, was not well adapted to resist the strains brought upon it during the process of lifting, notwithstanding the fact that the instructions of the Aermotor Company were carefully carried out in regard to the addition of temporary bracing to resist the bending stresses. The wind-wheel was geared down to work the pump in the ratio of $3\frac{1}{3}$ to 1. The diameter of the pump was 8 inches and the length of the stroke 16 inches, so that the theoretic discharge of the pump was 2·9 gallons per stroke. Careful experiments repeated a great number of times by recording the number of strokes required to fill the measuring tank showed that the average quantity of water delivered by each stroke of the pump was 2·5 gallons or 86 per cent. of the theoretic delivery. After preliminary experiments a daily record of the work done by the wind-mill was kept from the end of March 1902, and readings of the tacheometer were taken every morning at 8 A.M., at mid-day and at 4 P.M. It was at first intended to set up an anemometer to record wind velocities, but after careful consideration of the matter it was finally decided to dispense with the anemometer readings and to obtain all the information regarding the wind movements from the Observatory in Madras which is situated not much more than a mile away. The aermotor was 70 ft. above the ground and well above the influence of obstructions to the

Table I.

Observations made during the month of June. To face p. 71.

Date.	Hour.	Number of strokes of pump during interval.	Number of strokes of pump per day.	Wind movement in miles during interval.	Wind movement in miles per day.	Date.	Hour.	Number of strokes of pump during interval.	Number of strokes of pump per day.	Wind movement in miles during interval.	Wind movement in miles per day.
1	Noon.						Noon.	1,220		30	
	4 P M.	2,022		39			4 P.M.	1,188	8,755	34	196
2	8 A.M.	5,246		105		20	8 A.M.	6,347		132	
	Noon.	2 028		40			Noon.	1.827		34	
	4 P M.	3,783	16,220	50	269		4 P.M.	929	4,621	19	134
3	8 A M.	10.409		179		21	8 A M.	1,872		81	
	Noon.	3,059		47			Noon.	1,838		36	
	4 P.M.	3,718	17,412	60	283		4 P.M.	830	7,478	32	197
4	8 A.M	10.635		176		22	8 A.M.	4,810		129	
6	4 P.M.										
7	8 A.M.	7,912		142			Noon.	2,562		54	
	Noon.	2,880		49			4 P.M.	1.598	8,176	31	189
	4 P.M.	1,029		42		23	8 A.M	4,016		104	
9	8 A.M.						Noon.				
							4 P M.	668		23	
	Noon.	2,656		54		24	8 A.M	4,773		115	
	4 P M.	3,453	16,003	54	277						
10	8 A.M.	9,894		169			Noon.	1.793		35	
	Noon.	1.626		55			4 P.M.	2 262	12,720	41	226
	4 P.M.	3.501	14,492	56	261	25	8 A.M.	8,665		150	
11	8 A.M	9,365		150			Noon.	2,154		42	
							4 P.M.	2,707	12,971	47	230
12	Noon.					26	8 A.M.	8,110		141	
	4 P.M.	2,730		35							
13	8 A.M.	6.982		132			Noon.	1,590		37	
	Noon.	2.498		53			4 P M.	2 514	11,582	43	221
	4 P.M.	2.883	8,309	48	182	27	8 A.M.	7,478		141	
14	8 A M.	3,228		81			Noon.	1,737		40	
							4 P M.				
	Noon.	3,023		58		28	8 A.M.	7,003		127	
	4 P M.	3,403	9,561	48	185						
15	8 A.M.	3 135		79			Noon.	1,350		41	
							4 P.M.	1,631	6,968	38	179
	Noon.	3.350		62		29	8 A.M.	3.987		100	
	4 P.M.	2,732	8,141	44	171						
16	8 A.M.	2.059		65			Noon.	2.702		56	
							4 P.M.	4,325	13,621	58	243
	Noon.	1.886		39		30	8 A M.	6.594		129	
	4 P.M.	2.384	8.509	46	187						
17	8 A M.	4,239		102			Noon.	1.103		31	
							4 P M.	2.906	8,802	44	182
	Noon.	1 054		36			8 A.M.	4,793		107	
	4 P.M.	1.460	7,247	29	169	1st July					
18	8 A.M.	4,733		104							
	Noon.	1,227		29							
	4 P.M.	1,781	8,720	35	181						
19	8 A.M.	5,712		117							

wind caused by buildings and trees, and as the whole country for miles round, is a practically dead level plain, it was thought that, considering the observations were to be extended over a long period of time, it would be better to accept the Observatory anemometric determinations than to admit a new set with instruments not so carefully calibrated as those of the Government Observatory.

The aermotor has now been in operation for more than one year and sufficient information has been obtained to decide the question as to the suitability of these machines for irrigation work in India. Mr. R. Ll. Jones, the Deputy Director in charge of the Madras Observatory, has been kind enough to furnish me with a copy of the Observatory wind records for the whole year, and this statement gives not only the daily wind velocity in miles but also the movement of the wind in miles for every hour throughout the year. He has also been kind enough to furnish me with other data regarding wind movements in India of which, as will be subsequently seen, considerable use has been made in this paper and I am greatly indebted to him for his courtesy in this matter. Mr. J. Cook of the Central College, Bangalore, and Director of Meteorology in Mysore, has also been kind enough to send me valuable extracts from the records of his Observatories and I am glad to acknowledge my indebtedness to him for the same.

It seems unnecessary to publish the whole of the data which have been collected, but as a sample of the records for the whole year Table 1 summarizes the results of the observations made during the month of June.

To determine the ratio between the work done by the wind-mill and the daily velocity of the wind in miles was the main object of the experiments and this was easily done by plotting

the observations on section paper, taking as ordinates the number of gallons of water lifted 25 ft. per day and as abscissae the wind movement in miles per day. When the observations had all been plotted, it was found that a straight line having the equation

$$X = 175\ (Y - 53)$$

represented the results very satisfactorily, where X is equal to the number of gallons of water lifted 25 ft. per day and Y is the daily movement of the wind in miles.

General observations of the working of the wind-mill show that the strongest and steadiest winds generally blow in Madras from noon till about 5 o'clock in the afternoon, and from an examination of the Observatory records, it was found that, on a considerable number of afternoons during the year the wind blew with an almost constant hourly velocity, and from a selection of such days, a second curve was plotted having as ordinates the work done by the wind-mill from 12 to 4 P.M. and as abscissae the total wind movement during that period. The equation

$$X = 156{\cdot}87\ Y$$

represents these results with very great accuracy whenever the wind velocity averages more than 8 miles per hour during the period. Careful observations on several days with an anemometer fixed to the wind-mill tower showed that it required a steady breeze of about $7\frac{1}{2}$ miles per hour to keep the wind-mill in continuous motion, but that, when the wind velocity exceeded 3 miles per hour, a certain amount of work was done as the result of puffs of wind. From the first equation it will be seen that, when the daily wind velocity is below 53 miles per day, the amount of work done by the wind-mill is negligible but that above that velocity it steadily increases in direct

proportion to the increased rate of the movement of the wind. This same result is also obtained from the second equation, and it is one of extreme importance because makers of wind-mills invariably claim that the work done by a wind-mill is proportional to the cube of the wind velocity; and in their catalogues and price lists they publish fictitious tables showing the work done by the wind at various velocities.

Table II has been compiled from the average wind velocities measured at the Observatory in Madras during the 30 years 1864-1894, using equation (1) to determine the average amount of water which the wind-mill can lift.

The other columns in this table show (1) the depth to which an acre of land would be covered during the month by the water lifted by the wind-mill; (2) the average monthly rainfall; and (3) the depth of water which would be supplied to 10 acres of land by adding to the natural rainfall the quantity of water lifted by the pump. The months of February and October are the least windy in the year but during the former the harvest is in general progress whilst during the latter the rainfall is usually heavy. In March and April there is practically no rain, but the water delivered by the wind-mill would be more than sufficient for the seed-beds required for an area of over 10 acres. During May, June and July strong winds are prevalent and the water lifted by the wind-mill added to the average rainfall would cover a field of 10 acres to a depth of over 6 inches. This is sufficient with careful use for the irrigation of almost any crop, and I am therefore of opinion that a 16 ft. aermotor will do sufficient work in Madras to irrigate 10 acres of land when the water has to be lifted 25 ft.

TABLE II.

Month.	Wind; daily velocity in miles.	Rainfall in inches during the month.	Gallons of water lifted per day 25 feet.	Inches, depth on 10 acres per month.	Total rainfall and water lifted, inches on 10 acres.
January ..	144	0·89	15,920	2·18	3·07
February ..	122	0·28	12,070	1·49	1·77
March ..	152	0·39	17,318	2·37	2·76
April ..	191	0·62	24,140	3·20	3·82
May ..	227	2·12	30.450	4·09	6·21
June ..	220	2·11	29,215	3·87	5·98
July ..	198	3·87	25,380	2·47	7·34
August ..	174	4·56	21,180	2·89	7·45
September ..	156	4·69	18,020	2·39	7·08
October ..	123	11·00	12,240	1·62	12·62
November ..	165	13·21	19,600	2·60	15·81
December ..	182	5·28	22,740	3·11	8·39

Before discussing these results further, it will be well to give a brief *resume* of the results of experiments on wind-mills which have been made in other parts of the world. "The Water-supply and Irrigation Papers" published by the United States Geological Survey No. 20, give an account of an extensive series of experiments with wind-mills made by Mr. Thomas Perry. The experiments were carried out with extreme accuracy and with very elaborate apparatus and the results of them may be summarized as follow.

(1) The maximum work which can be done by a wind-mill is proportional to the cube of the wind velocity.

(2) The starting power of a wind-mill is proportional to the square of the wind velocity.

(3) The speed of an unloaded wheel increases in a somewhat greater ratio than the velocity of the wind, but for practical purposes there will be but little error in assuming that the unloaded wheel revolves at a speed proportional to the wind velocity.

(4) The best speed for a wind-mill is from 0·55 to 0·70 the speed at which it runs when unloaded.

(5) The best load for a wind-mill at any given velocity of the wind is from one-half to two-thirds the maximum starting force at that velocity of the wind.

A large number of experiments were made to determine the best form for the vanes of a windmill and the best result obtained showed that a 12-ft. wheel having an area of 113 sq. ft developed 6,836 foot-pounds of work in a ten-mile wind, or, in other words, that a 12 ft. wind-mill could be made to develop 0·207 H. P. in a ten-mile wind. This result is corroborated by experiments conducted in Denmark at the Government Experimental wind-mill erected at Askov. There it was found that the best result that could be obtained, when applied to a 12-ft. wind-mill would give 0·234 H. P. in a ten-mile wind. These results can be very approximately expressed in the following way. *The maximum work which can be done by a wind-mill in a ten-mile breeze is equal to one foot-pound per second per square foot of wind surface.* A 16-ft. wind-wheel has an area of 201 sq. ft. and should therefore supply in a ten-mile wind 201 foot-pounds of work per second equivalent to 0·373 H. P. From the equation $X = 156{\cdot}87\ Y$, it is found that the actual work represented by the water lifted is 0·198 H. P. or 53 per cent. of the maximum work that can be obtained from the wind. Allowing for the friction of the gearing and the loss of energy in the pump, the efficiency is satisfactory and the load on the pump is evidently suitable.

A careful consideration of these results leads to several very important conclusions which are entirely confirmed by the experiments on the aermotor. Although the maximum work which can be done by a wind-mill is proportional to the cube of the wind velocity the actual amount of work which it does when pumping water is proportional to the wind velocity, because the work done depends upon the number of strokes of the pump, and the number of strokes of the pump depends upon the velocity of rotation of the wind-mill, and this, we have seen, is approximately proportional to the wind velocity. This result is fully borne out by these experiments since the work done by the aermotor is found to be exactly proportional to the wind velocity. A similar result was obtained by Mr. W. H. Moreland, I. C. S., the Director of the Department of Land Records and Agriculture in the United Provinces, who, in "A Note on Trials of an Aermotor in Well Irrigation" published as bulletin No. II of the Agricultural Series of his Department, gives a table on page 3 which shows that the quantity of water raised at different velocities of wind was approximately proportional to the wind velocity. The practical meaning of this is that wind-mill works with the greatest efficiency when the velocity of the wind is just sufficient to keep it in steady motion, and, that at any other higher velocity of the wind only a portion of the useful work which the wind-mill could do is utilized. If a convenient arrangement could be divised whereby the load put upon the wind-mill varied with the square of the wind velocity the work done by these machines would be much greater. An attempt to realize this is made by the Chicago Aermotor Company who provide means whereby three different lengths of stroke of pump can be obtained, but in practice, it is found inconvenient to alter the length of the stroke. The most satisfactory way to vary the load on a wind-

Table III.

Mean hourly air movement at Madras (irrespective of direction.) To face p. 77.

——	January	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
Mid—1 ...	3·70	2 68	3·34	4·94	8·45	8·37	7·64	7·19	5·88	3·18	4·78	4·62
1—2 ...	3 37	2·48	2·93	4·10	7·90	8·42	7·56	7·25	6·00	3·20	4·59	4·49
2—3 ...	3 22	2 30	2·58	3·62	7·45	8·09	7·23	6·61	6·01	3·40	4·47	4·28
3—4 ...	3 15	2·28	2·52	3·41	7·21	8·01	6·86	6·51	6·02	3·55	4·73	4·04
4—5 ...	3·03	2 15	2·67	3·29	6·97	7·64	6·70	6·08	5·83	3·33	4·70	3·99
5—6 ...	3 00	2 20	2·53	3·16	6·84	7·17	6·33	5·77	5·53	3·24	4·52	4·08
6—7 ...	3 09	2·21	2·55	3·87	7·52	7·54	6·26	5·68	5·68	3·45	4·64	4·15
7—8 ...	3 43	2·82	4·16	6·92	9·82	9·34	8·02	6·85	7·08	4·60	5·59	5·15
8—9 ...	5·51	4 67	6·41	8·92	10·62	11·14	9·83	8·44	8·64	5·68	7·13	7·37
9—10 ...	7 66	6·38	7·78	9·86	10·78	12·28	11·21	9·51	9·54	6·43	8·72	9·72
10—11 ...	9 27	7·45	8·77	10·91	10·80	12·63	11·90	10·10	9·54	7·18	9·96	11·11
11—Noon. ...	10 11	8 43	10·14	12·53	11·76	12·72	11·97	10·12	9·56	7·59	10·77	12·01
Noon—13 ...	10 43	9·29	10·86	13·41	12·36	12·33	11·45	9·90	9·34	8·11	11·20	12·35
13—14 ...	11·13	10 06	11·68	14·16	13·31	12·51	11·42	9·97	9·21	8·64	11·38	12·69
14—15 ...	11·14	10·22	11·91	14·05	13·44	12·46	10·90	9·63	9·10	8·75	11·33	12·45
15—16 ...	11·04	10 14	11·91	13·89	13·31	12·09	10·59	9·15	8·53	8·49	11·28	12·25
16—17 ...	10·37	9 81	11·24	13·07	12·48	11·18	9·64	8·02	7·66	7·76	10·14	11·24
17—18 ...	8·75	8 50	9·70	11·41	11·59	10·18	8·77	7·35	6·26	5·84	8·21	9·03
18—19 ...	6 57	6·37	7·43	9·41	10·40	9·42	7·94	6·27	5·06	4·58	7·05	7·28
19—20 ...	5·86	5·43	6·53	8·40	10·03	9·00	7·86	5·95	5·13	4·07	6·58	6·74
20—21 ...	5·34	4 87	5·89	7·83	9·81	8·90	7·89	6·10	4·98	3·66	5·98	6·34
21—22 ...	4 91	4·48	5·41	7·22	9·70	8·80	8·09	6·71	4·91	3·44	5·68	5·92
22—23 ...	4·43	3·68	4·78	6·48	9·33	8·67	7·69	7·01	5·30	3·22	5·33	5·50
23—Mid. ...	4·07	3·30	4·09	5·86	8·86	8·43	7·57	7·26	5·65	3·24	4·95	5·11

mill is to provide it with two pumps worked through a rocking lever fixed at ground level. One pump can be permanently attached to the rocking lever and the other whenever the wind velocity is sufficient to justify doing so.

Table II has been compiled from the results obtained with a single pump of 8 inches diameter and 16 inches stroke, but it is certain that for the greater part of the year for several hours each day the aermotor would have been capable of working two such pumps with practically no loss of speed.

Table III gives the mean hourly movement of wind at Madras irrespective of direction and by using this table we can approximately estimate what extra work would have been done if it had been possible to attach a second 8-inch pump to the wind-mill whenever the velocity of the wind was sufficient to drive two pumps. With a wind velocity of 8 miles per hour and one 8-inch pump the wind-mill works steadily ; with double the load, since the power of the wind-mill is porportional to the cube of the velocity of the wind, a wind velocity of 10·08 miles per hour would be required.

From Table III, Table IV has been compiled by taking out for each month the average number of hours in the month during which the wind velocity was over 8 miles per hour, and also the number of hours in each month during which the wind velocity averaged over 10·08 miles per hour. From the totals it will be seen that the wind was strong enough during 3,791 hours to drive one pump and sufficiently strong during 1,985 hours to drive two pumps. This means, that, neglecting any work done by the wind when the average velocity was below 8 miles per hour, the total quantity of water raised by the wind-mill during the year would have been increased by 52·4 per cent. if another pump could have been attached when the wind was favourable. To drive three

pumps the wind velocity would have to be 11·54 miles per hour and the table shows that this velocity was exceeded during 917 hours in the year, so that the addition of a third pump would have increased the work done by a further 24·3 per cent. If a 10-inch pump had been attached to the wind-mill instead of an 8-inch pump, a wind velocity of 9·28 miles per hour would have been required.

Table IV shows that during the year the wind exceeded this velocity during 2,795 hours and the quantity of water which would have been lifted by the 10-inch pump would have been almost exactly equal to that which was lifted by the 8-inch pump, as when the 10-inch pump is working, it will in any given time lift 1·345 times as much water as the 8-inch pump. An examination of the figures given in Table IV shows that with the 8-inch pump the volume of water lifted is more uniformly distributed throughout the year than would be the case if the larger pump were used, and we may fairly assume that an 8-inch pump is more suitable for work with a 16-feet aermotor in Madras than a 10-inch pump would be. It is important to notice, however, that the difference is not very material and that, in places where the wind distribution is anything like that at Madras, the size of the pump may vary within considerable limits without materially affecting the quantity of water which would be lifted.

Table IV.

Number of hours in each month the wind movement per hour exceeded 8 *miles* (A). *exceeded* 10·08 *miles* (B), *exceeded* 11·54 *miles* (C), *exceeded* 9·28 *miles* (D).

Month.	A	B	C	D
January	248	186	...	217
February	196	56	..	140
March	248	186	93	217
April	360	240	180	360
May	558	341	217	496
June	630	300	210	360
July	372	217	62	279
August	279	62	...	186
September	240	...	...	120
October	120	...	...	...
November	270	180	...	283
December	270	217	155	363
Total ..	3,791	1,985	917	2,795

Table VI.

Number of hours in each month the wind movement per hour exceeded 8·28 *miles* (A), *exceeded* 10·43 *miles* (B), *exceeded* 11·94 *miles* (C), *exceeded* 9·50 *miles* (D).

	A	B	C	D
January	620	279	...	310
February	448	308	...	364
March	434	155	...	310
April	240	90	...	155
May	651	...	...	341
June	720	720	540	720
July	744	744	651	744
August	744	403	279	744
September	300	...	...	150
October	217	...	...	...
November	270	30	...	180
December	651	279	217	310
Total ...	6,039	3,008	1,687	4 328

Table V extracted from the Mysore Meteorological papers gives the mean hourly wind velocity during the four years (1895 to 1898) at Bangalore, and from this table we have constructed Table VI, similar to Table IV, in order to frame an estimate of what would be the work done by a similar aermotor in that locality. As the station is over 3,000 feet above the level of the sea, the density of the air is less and may be assumed to be 0·9 of that at sea level. As the work done by the wind is proportional to the mass multiplied by the cube of the velocity, a wind of 8 miles per hour at sea level will be as effective as one of 8·28 miles per hour at 3,000 feet elevation. The totals of the columns of Table V show, that a single 8-inch pump could be worked for 6,039 hours and that two pumps could be worked for 3,008 hours, whilst three pumps could be worked for 1,687 hours, giving an increase to the amount of water lifted of 50 per cent. for two pumps and a further increase of 28 per cent. for a third pump. If a 10-inch pump were used, it would work for 4,328 hours; this number multiplied by 1·35, the ratio of the work done by the two pumps in any given wind shows that the 10-inch pump would only lift 96·7 per cent. of the water lifted by an 8-inch pump, and an examination of the table shows that the greater part of this work would be done during the three monsoon months and that during the rest of the year the 8-inch pump would be immensely more effective than a 10-inch pump. From these figures, it would appear that the wind movements in Bangalore are so much stronger than in Madras that the work which a 16-ft aermotor would do would be 60 per cent. greater. It would be interesting to extend this method of investigating the prospects of a wind-mill to a number of other places in India, but the hourly data are not available, and we must content ourselves with the daily returns published by the Meteorological Department.

Table V.

*Mean hourly wind velocity—Bangalore.** To face p. 80.

	January.	February.	March.	April.	May.	June.	July.	August.	September	October.	November.	December
Mid—1	9·5	9·5	8·2	7·4	10·2	12·2	12·3	10·5	8·3	6·8	7·2	8·7
1—2	9·0	8·4	7·3	6·9	10·1	11·9	12·2	10·5	7·8	6·3	6·9	8·5
2—3	8·7	7·9	6·5	6·7	9·9	11·6	11·9	10·3	7·5	6·1	6·8	8·3
3—4	8·5	7·6	6·1	6·2	9·1	11·5	12·0	10·1	7·3	5·8	6·4	8·2
4—5	8·1	7·2	5·7	5·9	8·7	11·1	11·8	9·8	8·0	5·6	6·3	8·0
5—6	7·9	6·7	5·2	5·4	8·6	10·9	11·6	9·8	6·7	5·2	6·2	8·4
6—7	7·8	6·4	5·1	5·8	8·7	11·4	12·1	10·0	6·9	5·6	6·1	8·4
7—8	8·4	7·2	6·2	7·0	9·8	12·9	13·5	11·4	8·2	7·1	7·8	10·3
8—9	10·5	9·0	7·8	7·3	9·9	14·4	15·1	12·6	8·9	8·2	9·4	12·5
9—10	11·0	10·5	8·8	7·4	10·1	15·2	13·1	13·7	9·4	8·5	10·2	12·9
10—11	11·7	11·3	9·8	7·5	9·9	16·0	17·3	14·3	9·8	8·9	10·6	13·0
11—Noon	11·6	11·4	10·1	8·0	9·8	16·3	17·8	14·5	10·0	9·2	10·2	12·9
Noon—13	11·3	11·3	11·0	9·1	9·5	16·3	17·8	14·5	9·8	9·1	9·8	12·4
13—14	11·3	11·6	11·6	9·7	9·3	16·3	18·1	14·4	9·6	9·1	9·8	12·1
14—15	11·1	11·8	11·9	10·6	9·3	15·8	17·5	14·0	9·5	8·9	9·5	12·1
15—16	10·9	10·9	11·4	10·7	9·5	15·4	17·5	13·7	8·8	8·8	9·2	11·4
16—17	10·4	10·6	10·9	10·6	9·3	15·1	16·9	12·6	8·3	8·0	8·6	10·8
17—18	8·8	9·4	9·8	9·8	9·1	14·7	15·5	11·6	7·1	6·8	7·0	8·8
18—19	7·5	8·0	8·1	8·0	7·6	13·4	14·1	10·1	6·2	6·1	6·5	8·1
19—20	8·3	9·0	8·8	7·6	7·1	12·4	13·4	9·9	6·3	6·0	7·1	8·4
20—21	9·0	9·9	10·0	8·4	7·7	12·5	13·2	10·2	6·8	6·4	7·6	8·5
21—22	9·3	10·6	10·1	8·4	8·5	12·6	12·9	10·4	7·3	6·5	7·3	8·8
22—23	9·4	10·7	9·9	8·0	9.4	12·5	12·7	10·4	7·8	6·5	7·5	9·0
23—Mid	9·4	10·3	9·2	7·7	10·0	12·1	12·4	10·4	8·0	6·9	7·5	8·9
Total ...	229·0	227·2	209·1	189.8	220·8	326·9	345·9	279·5	193·1	172·2	191·3	239·0

* The figures in this table are taken from the Memoirs of the Mysore Meteorological Department and are not comparable with the figures for Bangalore in Table VII.

In Table VII the average daily wind velocity for each month in the year for some 28 stations fairly, evenly distributed over India is given.

We have seen that the work done by the aermotor in Madras is proportional to the daily velocity of the wind, the equation being $X=175(Y-53)$. Applying this equation to the figures giving the average daily velocity throughout the year we obtain the ratio given in the horizontal line $\left(\frac{M-53}{165-53}\right)$. This method is based upon the assumption that an 8-inch pump is in use. But in places of low-wind velocity it would be advisable to use a smaller pump, and in places of much higher wind velocity better results will be obtained with a larger pump. We have seen that the energy of the wind is proportional to the cube of the velocity and that the starting power of the wind is proportional to the square of the velocity, and it therefore seems not unreasonable to assume that the energy which can be derived from the wind may be taken as approximately equal to the square of the daily wind velocity. In Table VII is given the ratio of the average wind velocity at each place to the average wind velocity in Madras $\left(\frac{M}{165}\right)$, and the squares of these numbers $\left(\frac{M}{165}\right)^2$. A comparison of the two sets of figures, $\frac{M-53}{165-53}$ and $\left(\frac{M}{165}\right)$ shows that only in places of extremely low or extremely high wind velocity there is any very material difference, and for this reason, I am inclined to think that the latter method of estimating the probable amount of work which can be obtained from a wind-mill in any locality is the more accurate.

It will be seen that at the great majority of stations the wind forces are so slight that we may unhesitatingly say that wind-mills are of no value. There remain, however, a certain number

of stations where the conditions are favourable, and as these represent the wind conditions prevailing over an enormous tract of country, we arrive at this result: that though over the greater part of India including the whole of Northern India, the energy of the wind is of no practical value, yet there are many places in peninsular India where it should be profitable to make use of wind-mills for irrigation. Along the sea coast from Karachee to Bombay and from Diamond Harbour to Negapatam over a large tract of the Deccan, over the Mysore Plateau and probably in most of the hill stations, it will be found that wind-mills if not absolutely ideal machines for lifting water, are by far the cheapest and most convenient of mechanical devices available. From the equation which has been obtained as the result of observations in Madras, it is easy to calculate the effective horse-power obtained from a wind-mill, and it will be seen that when the load is fixed, as it is by the size of the pump and the height over which the water is lifted, the actual horse-power of the wind-mill is not very large even when strong breezes are blowing. On the other hand, it must be remembered that a wind-wheel of from 12 to 20 ft. in diameter would be sufficiently large to extract all the water that can be obtained from the majority of wells sunk in this country, and that, as it is most effective in hot dry weather, it is a more convenient aid to irrigation than at first sight might be expected. We have seen that the amount of effective work which a wind-mill can do is increased 50 per cent. by the addition of a second pump, and as the cost of this addition is comparatively small compared with the cost of a wind-mill tower and one pump, I strongly recommend that all wind-mills erected for lifting water should be arranged so as to be able to drive two pumps during periods when the wind velocity is sufficiently high. Taken as a whole, the movements of the wind

in India, though very much feebler than in temperate climates, are fairly reliable and conveniently distributed, the maximum wind force usually occurring in the afternoon when the water in the well will probably be at its lowest level and the work of lifting it out therefore greatest. It may also be noted that, as a rule, during rainy weather the wind movements are feeble, but water for irrigation is not wanted then; whilst hot dry weather, when water is most wanted, is usually accompanied by strong winds. The actual results of irrigation with aermotors should therefore be somewhat more favourable than calculations based on average returns indicate.

As the result of experience with the working of the aermotor supplied by the Chicago Company, I am of opinion that these machines are not sufficiently strongly constructed for work in India. A good many minor breakages have occurred during the course of the experiments, but the most serious defects were due to the bad fitting of the valves in the pump chamber. The design seems to be excellent but the execution was bad and much trouble might have been obviated if the pivots on which the flap valves turn had been made larger and fitted into better designed sockets. A wind-engine and pump cannot be placed in inexperienced hands; they require carefully looking after, and the slightest defect or damage should be remedied immediately it occurs. It will not pay to keep an experienced fitter to look after a single wind-mill, but the man could easily look after a dozen mills and where such colonies of wind-mills can be establised they will prove extremely remunerative investments.

A 16-feet aermotor mounted on a 40-ft. tower and fitted with an 8-inch pump will cost, when erected over a well, about Rs. 1,500, and we may assume that the cost of maintaining the same in good order will be about Rs. 5 a month. Such invest-

ments should yield about 6 per cent. interest on the capital expended, or Rs. 7–8–0 a month. Ten per cent. for depreciation is perhaps an excessive amount to allow, but it will be well on the safe side if we do so. This comes to Rs. 12–8–0 a month, making the total cost of the wind-mill Rs. 25 a month. Now, this wind-mill will do as much work as at least 2 pairs of good cattle, and if fitted with two pumps it will be equivalent to 3 pairs of cattle and the cost of lifting water with them will amount to from Rs. 45 to Rs. 67 a month, showing a margin in favour of the wind-mill of from Rs. 20 to Rs. 40 a month. This is the result that can be obtained in Madras, but there are thousands of square miles of country in India where much more favourable results can be obtained, and I therefore conclude this brief account of my observations on a wind-mill in Madras with the statement that there is a wide field in India open for the profitable employment of wind-mills in lifting water for irrigation.*

* Reprinted from the *Indian Review* for June 1903.

AGRICULTURAL EDUCATION.*

In India the state owns the greater part of the soil and its revenues are mainly dependent upon the agricultural prosperity of the people. It might therefore be expected, that in any schemes for technical or industrial education, the claims of agriculture would be considered of paramount importance and that every effort would be made to bring to its aid all the resources which modern progress in Science and Engineering has placed at the disposal of the tiller of the soil. Under the direction of the Departments of Land Records and Agriculture in the different Provinces much desultory work has been done in the past and comparatively recently, the Government of India have taken up the matter seriously and by the appointment of a Director-General of Agriculture and an Agricultural Chemist, have initiated a movement which, in the future, may be expected to yield valuable results. It is generally admitted that the condition of agriculture is far from uniform throughout the country. Whilst in some places it is in a very backward and primitive condition, in others it is highly developed and capable of but little improvement. Dr. J. A. Voelcker, the Consulting Chemist to the Royal Agricultural Society, England, in his report in the year 1893 to the Government of India on the "Improvement of Indian Agriculture" referring to the garden cultivation in Coimbatore, wrote, "There is nothing or, at all events, very little that can be bettered here." And the general opinion

* Reprinted from the *Indian Review* for August 1903.

formed by that expert is not unfairly represented by the following extracts from his report:— "At his best the Indian ryot or cultivator is quite as good as, and in some respects the superior of, the average British farmer, whilst at his worst it can only be said that this state is brought about largely by an absence of facilities for improvement which is probably unequalled in any other country, and that the ryot will struggle on patiently and uncomplainingly in the face of difficulties in a way that no one else would. What does however prevent them from growing larger crops is the limited facilities to which they have access such as the supply of water and manure. But to take the ordinary acts of husbandry, nowhere would one find better instances of keeping land scrupulously clean from weeds, of ingenuity in device of water-raising appliances, of the knowledge of the soils and their capabilities, as well as of the exact time to sow and to reap, as one would in Indian agriculture; and this, not at its best alone but at its ordinary level. It is wonderful, too, how much is known of rotation, the system of mixed crops and of fallowing. Certain it is that I at least have never seen a more perfect picture of careful cultivation combined with hard labour, perseverance and fertility of resource than I have seen at many of the halting places in my tour." Practically, this definitely expressed opinion has long been intuitively felt by those in charge of the agricultural interests of the country and so little has been done because so little was possible. Before we can teach the ryot we have to learn ourselves and the knowledge that is necessary can only come from a long course of carefully devised experimental work at farms suitably arranged for the purpose. But, whilst we may freely concede that the ryot at his best has evolved a system of agriculture which is but little short of perfect, few, I think, will gainsay the fact that

his methods of procedure are laborious, and his equipment of tools more distinguished for their simplicity of construction than for the effectiveness of their operation. It is in this respect, I think, that a properly devised system of industrial education might in the immediate future effect much for the benefit of the ryot.

The poverty of India is a theme often dwelt upon and many and varied are the proposals which have been made to lessen it. The establishment of technical and industrial schools has been strongly urged and it may be accepted without cavil that a good system of industrial education is, at any rate, one and a not unimportant step in the right direction. We hear a great deal about the enormous undeveloped natural resources of the country but the area over which they are scattered is equally enormous and the population dependent upon them is one-fifth of the human race. Relatively to other countries we must accept the fact that India is very poor but, except during periods of famine, the climate is such that the hardship and suffering, experienced by the poorest classes in much wealthier countries, is hardly known in India. The great wealth and luxury of the present day is, in the main, due to the fact that the toil of production and manufacture has been to a large extent eliminated by the extensive use of machinery, and nations are rich in proportion to the extent to which they have been able to avail themselves of such aids. Compared with Western nations India is still a country of manual labour, yet, there has been a considerable increase in wealth, going on during the past half century and, it is largely due to the introduction of machinery to supplement hand labour. Railways have enormously decreased the cost of transportation and the steam power and machinery employed in the cotton mills, jute mills, flour mills and other factories have added to the productive power of the country

without increasing the number of consumers. Manual labour and animal power are feeble things compared with modern machines and modern motors; and the more we can displace or supplement the former by the latter, the more readily will wealth increase. Obviously, therefore, one of the functions of industrial schools should be to encourage the use and development of mechanical appliances, and, though from want of capital and other causes it may be a long while before any great progress is made in this direction, yet it is clearly the direction in which our work should tend.

What should be the aims and objects of industrial schools,has never been quite clearly stated and as there is much confusion of ideas on the subject even amongst those who are concerned in the management of them, it may be convenient to briefly enumerate them now. They are, (1) the substitution of machinery for manual labour; (2) the improvement of the hand-working tools and appliances at present in use and the introduction of entirely new ones; (3) the teaching of accurate methods of working and the demonstration of the advantages to be derived from production on a large scale; (4) the introduction of new materials and new methods of working; and (5) the introduction of entirely new trades.

Accepting these principles for our guidance in establishing and developing industrial schools, it remains for us to enquire how they may be applied so as to render assistance to the agricultural community. The main requirement of the ryot is water and if we can assist him to obtain water on more favourable terms than at present, we materially improve his position. Under the Perennial Irrigation Works constructed by Government, there are large tracts of country with a more than adequate water supply whilst there are equally large tracts which derive their water supply

from tanks which fail only when the seasons are extremely unfavourable. The ryots under these irrigation works obtain their water with practically no trouble, but there is a large area of land under cultivation with water derived from wells which yields probably the most valuable crops in the country. The water supply is fairly certain but it can only be obtained by the exercise of patient unremitting toil. In Fasli 1310 there were in the Madras Presidency 468,342 wells irrigating nearly a million and a quarter acres of land and a further extensive area of land was partially dependent for its supply of water upon 149,373 additional wells. These figures are very large but compared with the whole of the cultivated area of the Presidency which in the same Fasli amounted to 22,835,000 acres the percentage is not very large. In the future the area protected by major irrigation works will doubtless continue to increase but, in the main, if Indian agriculture is to be materially improved, we must look to a considerable extension of well-cultivation for the same.

In previous articles contributed to this Review and in Bulletins of the Department of Land Records and Agriculture, I have discussed certain questions intimately connected with the extension of well-cultivation in this country and I have arrived at some conclusions which it will here be necessary to briefly re-state, in order that what follows may be clearly understood.

(1) For lifting water from wells, rivers or streams, the ryots are dependent upon appliances of exceedingly simple construction which are either worked by themselves and their labourers or by cattle. From careful measurements of the out-turn of work with these machines for lifting water, it appears to me that there is no prospect of being able to effect any such improvements as would materially affect the conditions of Indian agriculture. The cost of lifting water has been determined with as great

an amount of accuracy as is possible, and data have been obtained to enable a fair comparison to be made between, what I may term, native methods of lifting water and those which are dependent upon mechanisms and motors of modern origin.

(2) I have drawn attention to the comparatively small volume of water made use of in well and garden cultivation and have adduced evidence to show that there is probably a much larger quantity available within the reach of more powerful pumps. Lack of capital and inability to understand and keep in working order mechanical appliances have hitherto proved insuperable obstacles to any progress in the adoption of such means whereby the toil of the cultivator might be lightened and his energy directed to the more profitable channels.

(3) The cost of generating power by oil-engines has been determined from data collected in the course of practical working with a number of such motors and it has been conclusively proved that under suitable conditions the cost of lifting water with oil engines and centrifugal pumps is not more than one-half the cost with cattle, working under the most favourable conditions. The experience of other countries is exclusively in favour of the the employment of mechanical rather than animal sources of motive power and no satisfactory facts have ever been brought forward to show that the circumstances in India are different.

(4) It has been generally held that the wind velocities in India are too small to permit of the profitable utilisation of the wind power. The results obtained by experiments in Madras carried on throughout the whole year have led to an important modification in this opinion and from an examination of the wind velocities recorded by the Meteorological Department it has been proved that there are very extensive tracts of country, mainly in peninsular India, over which the wind-movements are sufficiently

strong to make it worth while to employ wind-mills for raising water. Further information corroborating these results has been obtained since they were first published, and it is now established beyond reasonable doubt that, where the circumstances are favourable, wind-mills will prove economical substitutes for cattle in the lifting of water from wells for irrigation.

Ten years ago there seemed to be very little prospect of the antiquated methods of the ryots being improved upon, but within the last decade enormous improvements have been effected in the methods of generating power and it is desirable that in India, the most should be made of them as early as possible. The difficulties in the way of bringing mechanical methods of lifting water to the assistance of the agriculturist are undoubtedly very great and are probably so great that for sometime to come it must rest with the Provincial Government, the District Boards and possibly the Court of Wards to carry on the work which has already been initiated by Government and for which certain funds have been provided at the instance of the Irrigation Commission. Viewed from our present stand-point, however, the agricultural problem is by no means solved when we have provided motors and pumps for lifting water. We must go a great deal further than this. We must endeavour to get the ryot out of his present state of mechanical inaptitude and give him such a training as will enable him, not only to appreciate the advantages of labour saving appliances, but put him in a position to be able to take advantage of them himself. It seems to me that properly constituted rural industrial schools will best meet the necessities of the case, but if much good is to be derived from them it is necessary that they should be numerous, and evenly distributed throughout the country. There are probably but few Taluks in this Presidency which would not be immensely bene-

fitted by the establishment of such schools in suitable localities, where they will serve both as demonstration farms for the benefit of the adult ryot community and as schools in which their children can be trained in the best practices of modern agriculture. 150 such schools would be one to nearly every Taluk in the Presidency and one to every 150,000 acres of cultivated land. Probably these schools, when completely equipped, would cost, on an average Rs. 10,000 each or Rs. 15 lakhs for the whole Presidency. The interests involved are very large and adequate means must be employed if really important results are to be achieved. In the main, I think, it would be desirable to place these schools under the management of District Committees who would be guided, or perhaps it would be better to say directed, by an experienced officer appointed by Government. In part, no doubt, the funds could be raised by local subscriptions and possibly Government might be able to make considerable advances under the Agricultural Loans Improvement Act. Several years would necessarily be occupied in the establishment of these schools and if the initial outlay were provided, I think it is quite possible that the District Boards would be able to find the money to maintain them. It must be remembered that they are to be practical institutions and that their object is to deeply influence, in a beneficial way, the agriculture of the districts. If they achieve their objects, the expenditure on them will be but small compared with the benefits that will be obtained, and the most impecunious District Boards may well consider that they are laying out the funds at their disposal to the best possible advantage, when they are expending them in a direction which is likely to bring about a material increase in the wealth and resources of the districts.

The rural industrial school will bear but little resemblance to existing institutions which are all situated in urban localities.

The head of it should be an agriculturist, a man well versed in the best methods of cultivation that are possible in the district; not necessarily a graduate of the University or even a failed matriculate. His qualifications should be of a practical order and he should understand, not merely how to farm, but how to do so with profit. He would be provided with a house and entitled to a share in the produce of the farm so that his actual remuneration in money would be comparatively small. Similarly with the assistants, farm labourers, and pupils. Each and all of them would live on the farm, would enjoy the usual luxuries of an agricultural life and would receive their pay or remuneration almost entirely in kind. At the outset, at any rate, it will be extremely undesirable for either the farm Superintendents or the other employees attached to these agricultural schools, that any of the provisions of the Educational Department should be made to apply. Later on, when they have become firmly established and their value recognised throughout the country, it will be wise no doubt to try and increase their efficiency by insisting upon the possession of general educational qualifications both by the staff and the students. But at the beginning the main object will be to influence the ryot, and that can only be done by practical demonstrations which can be clearly understood and appreciated by unlearned and ignorant people.

In selecting a site for one of these rural industrial schools, I regard an ample supply of water as the prime necessity of the case, and it must therefore be in a place where there is either a good supply of well-water or a water course from the sandy bed of which an ample supply can be obtained. For raising this water the school should be equipped with an oil engine and centrifugal pump and, in places where the meteorological conditions are favourable with a wind-mill and reciprocating pump. Round the school

there should be a sufficient area of land to utilise in the most profitable manner possible all the water raised by both the engine and the wind-mill. As the smallest sized engine which can be recommended for pumping purposes is one which is capable of irrigating at least 35 acres of land, this practically fixes the minimum requirements of the school both as to land and water supply. But where an ample water supply exists there is no reason why the school should not be equipped with a much larger engine or in some cases with more than one engine and if the area of the land which can be cultivated by the water raised by this engine is larger than can be conveniently managed by the school authorities, it will be extremely desirable to sell the surplus water to neighbouring cultivators if they are willing to pay for the same. The land attached to the school should be cultivated as far as possible by the pupils of the school. It should be treated as a farm working on commercial lines and experimental cultivation should be considered quite a secondary matter. The object should be, not to improve cultivation so much as to demonstrate the possibilities of the best known systems of cultivation. Besides the agricultural class, there should only be one industrial class in the school and all the pupils should go through the same course of training. The object of this class should be to turn out mechanics or artizans who will be capable of managing all the improved implements of agriculture which by experience it has been found may be profitably introduced. There should be instruction both in carpentry and iron work and the object should be to turn out carpenters and smiths and not cabinet makers or fitters. In the wood shop, the boys should be taught house building, construction of carts, wheels, ploughs, seed-drills, water-lifts, and any other appliances which will be useful to the agricultural community. In the blacksmith's

shop they would undertake all kinds of miscellaneous repairs. They would make axles for carts, tires for wheels, mamotees, jumpers, ploughs, reaping knives and hoes and, would be familiarised with the use of machinery. The boys would also be taught to manage all kinds of machinery which are likely to prove of any use in the furtherance of agriculture.

And though no two schools would be equipped exactly alike, in the majority of them it would probably be desirable to place such machines as an oil-press, a sugar-cane mill, vacuum pans for the extraction of sugar, a winnowing machine, a chaff cutter, and a cotton gin, besides other appliances which might be considered to be specially suited to local agricultural requirements. The wind-mill should be regarded as a supplemental source of power to the oil engine and the latter might easily be arranged to drive such of these machines as require more than a small amount of power. I would not only allow, but would distinctly encourage, the ryots in the district to make use of these machines; to bring their oil seeds to the press to have the oil extracted; their sugar-cane, to the mill to be crushed or their cotton to be ginned; and I would charge them just enough to cover the actual cost of these operations, so that they might learn by practical experience the advantages of these machines. For instance, I would extract castor oil from the seed and receive the poonac or oil cake in payment for the work. This seed cake I would use as manure for the land probably where sugar-cane was cultivated and when the same reached maturity I would crush the cane and return everything to the land except the actual sugar. The elements entering into the compositions of oil and sugar are ultimately derived from the atmosphere and such a system of cultivation would therefore deprive the soil of none of the constituent elements essential to the healthy growth

of the crops. In some cases the schools would be in localities where wells are numerous, and as the first step towards the improvement of the means of raising water the school might undertake to maintain in order water-lifting appliances belonging to the adjacent ryots. Under such a system it would be possible to give the double mhote a proper trial and many improvements could be introduced into the water bags which are now such a fruitful source of worry and trouble to the owners.

Either by growing them on the farm or by supplies derived from the immediate neighbourhood it would be possible to obtain all the more valuable Indian fibres, and in the school the machines for extracting them could be made and the methods of using them demonstrated. In some districts it would be desirable to go in for silk culture, to grow the mulberry leaves or other food suitable for silk worms, to rear the worms and to introduce better processes of silk winding. Mr. Tata of Bombay has established an experimental silk farm at Bangalore and a good deal of valuable experience and information has been gathered by the Japs employed there to look after the work. He has introduced Japanese methods of culture with results which are, I understand, very satisfactory in many respects and from a personal inspection of the processes, I am certain that there is nothing in the system adopted there, which could not be easily carried out in any place favourable to the culture of silk worms. It will thus be seen that these schools will be places for demonstrating the best practical methods of obtaining the proceeds of the soil and of manufacturing these products into commercial commodities with as little waste both of raw material and energy as is possible.

More directly connected with the agricultural side of the school than with the workshops, would be the gardens, orchards, poultry yards and stockyards which I should like to see establish-

ed and in nearly every case I think it would be desirable to run a small dairy for the purpose of manufacturing butter and ghee any surplus of which might be exported to places where it would command a fairly ready sale.

I do not presume to suppose that it would be possible to carry out all the suggestions which I have made, in any one place, nor do I consider that it would be feasible to start them all at once. I would commence operations by providing the water supply and selecting the site of the farm and it is in this matter that our experience is the least and the chances of mistakes the greatest. At the outset there would be considerable difficulty in obtaining suitable persons to manage the farms and control the workshops, but those are difficulties by no means insuperable and would greatly decrease as experience accumulated and the success of one venture after another became assured. I have already stated that the establishment of such schools would require on an average a capital outlay of Rs. 10,000, but if they were properly worked the returns from the farm and from the workshops would meet, if not the whole, yet a very considerable portion of the working expenses. Herein really lies the root of the whole matter. For, if, when these schools are properly established, they cannot be made to pay their way, they must be regarded as failures. No ambitious agricultural programme is to be attempted. All that is to be taught is good farming and the management of agricultural machinery and of only such agricultural machines as, with fairly skilled mechanical labour, an advantageous use can be made of in this country. In garden cultivation, in fact in all cultivation under wells, the cost of raising water and of applying it to the soil is, by far the heaviest item of expenditure and since in these schools this item would be at least one-half of what it now is to the ordinary ryot, the margin for

successful working is a fairly wide one. Under proper management no difficulties should be experienced in making both ends meet. Such schools will, I am sure, attract the attention of the larger landholders and men of wealth in the districts, and I am pretty certain that if suitable accommodation is provided for them at or near the schools, they will visit them in large numbers for the purpose of gaining practical information regarding the working of the various appliances which it will be one of the objects of the school to introduce. In this matter it seems to me not improbable that they might be induced to subscribe among themselves the necessary funds to provide for their own accommodation.

Now, what will be the result of all this expenditure? And will the ultimate results justify the application of so large an amount of capital? It must be remembered that the interests affected are the most important in the country and represent by far the greater part of the wealth of the people. One hundred and fifty farms with an average area of 40 acres each would cover, but 6,000 acres of land and would be but approximately 1/4000th part of the total area under cultivation. Fifty wind-mills and one hundred and fifty oil-engines may seem a fairly large number but their total horse-power would be less than thousand as compared with about a quarter of a million horse-power which expresses the total capacity for work of all the cattle now employed in this Presidency in lifting water. Thus it will be seen that, though I advocate a large expenditure when measured in absolute figures, yet, relatively to the interests involved it is comparatively small, and it may therefore be fairly assumed that even comparatively trivial results may become of importance when spread over so wide an area. In the first place, I think, that not a few of the ryots will send their

sons to the schools to go through a course of practical training on the farms and to pick up a little mechanical knowledge in the workshops. In the second place, the schools will be able to supply the districts or taluks in which they are situated with improved tools of local manufacture and of such design as experience has proved, will suit the requirements of the ryots. If the results of lifting-water by mechanical means prove satisfactory and they can hardly fail to do so if the site in the first instance is carefully selected it will induce some of the wealthier landed proprietors and zemindars to set up similar installations on their own property, and they will the more readily do this when they find that without difficulty they can secure the services of competent men to look after them. Gradually the number of these installations will increase and though it may be taking a somewhat sanguine view, it does not seem to me to be utterly beyond the bounds of possibility later on to imagine that combinations of ryots may be formed to provide themselves with these means of extending their cultivation for which, individually, their capital is insufficient.

Now that power can be had so cheaply and can be distributed by electrical means with such great facility, there are not a few localities in which, even at the present time, I think a properly organized power distribution scheme would pay. Where wells are very numerous and garden cultivation extensive, the electrical distribution of power to drive centrifugal pumps by electro-motors seems quite feasible and all that is required is to educate the people of the country up to realising the advantages which may be derived from such methods. From all I can learn, it is the want of capital that prevents the extension of well cultivation and it is the lack of wells and of the means of raising water from them, that renders

it necessary to leave so large a proportion of the cultivated area under dry crops. There is but little doubt that the area under well cultivation might easily be doubled, possibly trebled, and the attainment of any such result as this would be of enormous practical importance. With a sufficient supply of water the cattle can be used, as in other countries for farm work and with the greater amount of cattle labour available, a more perfect system of tillage can be followed. I am not an agricultural expert and therefore I can offer no opinion upon such vexed questions as deep-ploughing *versus* surface scratching of the soil. But I am inclined to think that if more cattle were available, in many parts of the country the soil is such, that deep ploughing might probably be adopted with advantage. At any rate, if the ryot be relieved of the drudgery of water-lifting under existing conditions and provided with better implements and taught in the industrial schools to handle them properly, then, there can scarcely be any doubt but that there will be some breaking away from the hide-bound traditions of the past and that such disruption will mark the dawn of a new era in Indian agriculture in which Nature will be assisted by Science and the land will yield us fruit abundantly in response to the intelligent demands which are made upon it.

INDUSTRIAL PROBLEMS.

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TANNING
IN
THE MADRAS PRESIDENCY.

The manufacture of inferior kinds of leather was an indigenous industry which existed in this country from probably very early times and, in an extremely primitive condition, it remained till nearly the middle of the 19th century when the initial steps were taken to improve the tanning of skins, which have led to the establishment of an export trade which is now of immense importance. The average value of the hides and skins exported from this Presidency, either in a raw or manufactured state, has during recent years averaged nearly three crores of rupees and forms about one-fifth of the total value of the exports. In the year 1847 they amounted to only Rs. 70,000, to which tanned skins contributed less than Rs. 1,500 so that the whole of this trade has been developed within the last 65 years.

The first attempts to introduce improved processes of tanning were made by a French-Eurasian of Pondichery named Charles De Susa who visited the Isle de Bourbon in the forties and there acquired a practical knowledge of tanning. On his return to Pondichery about the end of the forties he started a tannery there, and a little later, he came to Madras and set up tanneries, the products of which were probably exported to England. At that date he is said to have been able to purchase goat skins at Rs. 14 per hundred and of *avaram* bark there was then, as now, abund-

ance, so that with raw materials at such a low price, it is not surprising that he soon acquired a large business connection and his success led many others to embark in the trade. He introduced many important improvements in the native processes of tanning and he was probably the first tanner who succeeded in turning out a leather which preserved its colour after exposure to the air, and this he did by completing the tanning processes with a bath of myrobalam extract. At first the tanning trade was largely in the hands of Eurasians but they were very soon cut out by Muhammadan and native tanners.

In the report of the Madras Exhibition of 1855 it is stated, "The manufacture of leather in this Presidency is, by no means, so thriving as it might be, considering the great abundance of tanning materials at command. This is probably owing to the very low rank of the artizans, for the art of leather production is well understood and successfully practised by the European tanners at Pondichery, Hoonsur, Guntur, Bangalore and Madras, the leather being scarcely inferior to that made in Europe. Goat-skins, sheep-skins, buffalo and bullock hides are much used and are generally procurable but are very badly dressed; currying the leather being the province of the shoe-maker's wife, whilst manufacturing it for the market belongs to the husband. Inferiority of Indian leather may, therefore, be ascribed to want of skill on the part of the currier and to the use of quicklime."

About the time that Charles De Susa was starting tanneries in Madras and Pondichery, the Military authorities established a tannery at Hoonsur for the purpose of manufacturing leather suitable for harness and other military equipments. At the Madras Exhibition of 1857 the importance of this growing industry was fully recognized and the report of the Jury, who made awards in this class, contains a large amount of information and

some critical remarks of considerable value. The tanning trade continued to be steadily developed till nearly the middle of the seventies when various causes operating at the same time led to a very rapid expansion. Up till that date the skins were consigned to dealers in England who disposed of them privately; but then, a change was made and public auctions were established. The conclusion of the Franco-Prussian war was followed by great industrial activity on the part of Germany and about 1875 German tanners commenced buying East-Indian skins in large quantities. In August of that year the export duty on skins was repealed and, followed as this was, almost immediately, by the great famine of 1876 and 1877, which was attended with immense mortality among the livestock, an enormous expansion in the export trade in hides and skins took place, which has ever since been maintained. Lastly and perhaps of the greatest importance was the completion of the main trunk lines of railways which enabled the Madras tanners to obtain supplies of raw material from a greatly extended area.

From all the great seaports of India—Calcutta, Bombay, Madras, Karachi and Rangoon—there is a considerable export trade in hides and skins; but it is only from Madras and Bombay, and chiefly from the former, that these articles are sent out of the country in a partly manufactured state. As regards Madras, the exports of raw hides have always been very small and previous to the year 1899 there were no exports of raw skins. But in the latter part of that year the export of raw skins commenced on a very large scale and still continues. The tanned hides are exported in a half-manufactured state to be re-tanned and curried by the leather manufacturers of England and the Continent. Up to the present time there has been no material change in the condition of this trade but it is not impossible that the causes which have led

to the export of raw skins in such enormous quantities during the last four years may also, at some later date, affect the business now carried on in Madras in tanned hides. It must be remembered that, large as the Madras business is in hides and skins, that of Calcutta is much larger and nearly the whole of the Bengal trade has always been in raw hides and skins. The export trade from Madras being mainly in tanned skins has never been entirely dependent upon local supplies, as large quantities of skins are brought down to Madras, to be tanned, from the Punjab, United Provinces, Central India and parts of the Bombay Presidency. It is, therefore, not unlikely that if the demand from Europe and America continues to increase for raw skins the total volume of exports from Madras will decrease owing to the shipment of raw skins from other and more favourably situated ports ; those of the Punjab being sent to Karachi, those of the United Provinces to Calcutta and the skins of Central India and the Bombay Presidency to Bombay. So far, there are no indications of a shrinkage in the total number of skins exported and the change effected seems to be simply that the skins are exported in a raw, instead of a tanned condition.

The cause of the demand for raw skins is entirely due to the popularity of a new kind of leather which is now largely produced in America and on the Continent by one or other of what are known as the chrome processes. Chrome tanning was first experimented with fully 50 years ago, but no great progress was made with it till within the last ten years and it was only in 1895, that chrome tanning was thoroughly established in America on a firm commercial basis. The process may be described as a purely chemical one requiring a considerable knowledge of chemistry and an accuracy in manipulation which can only be expected from specially trained men.

The product, chrome-tanned, or more properly speaking, 'tawed' leather is, in many respects, superior to leather made by any other process and for certain purposes it has probably displaced vegetable tanned leathers permanently. Compared with other tannages, chrome produces a leather which, whilst exceedingly soft and pliable, possesses great strength and is practically unaffected by water. Moreover, it is less liable to stretch than other leathers and this important property makes it specially suitable for the manufacture of boots and shoes. Chrome-tanned leather may be boiled for several minutes with impunity or exposed to strong heat for some time without risk of injury; and these valuable properties add greatly to its wearing qualities. Once chrome tanned leather is thoroughly dried, it is exceedingly difficult to wet it again and it is therefore necessary that the finishing processes should be undertaken as soon after the tanning as possible. This is a matter of great importance to this Presidency because hitherto the tanners have not attempted to produce for the export trade anything more than half-tanned goods and it is practically impossible to introduce chrome tanning unless at the same time arrangements are made to complete the process of converting the skins into marketable articles. The opinion is almost universally held amongst those engaged in trade in Madras that it is impracticable to produce finished goods cheap enough and, at the same time, of sufficiently good quality to enable them to be exported at a profit. Attempts have certainly been made both in Madras and Bombay and there is no doubt that they have ended in failure, although one Parsee tanner claims to have succeeded; but as yet he has furnished no evidence that he is able to carry on operations at a profit.

At any rate, there is no doubt that the successful establishment of an export trade in chrome leather from India can only be

accomplished in the face of great difficulties which may be briefly classified under three heads :—

(1) *Want of capital:* A chrome tannery with the accompanying leather-dressing shops requires a large amount of machinery and, apparently, can only be successfully worked on an extremely large scale. In America one firm is said to be capable of turning out 3,000 dozen finished skins a day and another to have a capacity of fully 2,500 dozen skins, so that these two firms alone could easily deal with all the exports of this Presidency. Of course it will not be necessary to establish tanneries in this country on that gigantic scale; but it will be necessary to invest a large amount of capital with dubious prospects of success, and under such circumstances it is quite hopeless to think that the capital will be forthcoming.

(2) *Want of intelligent labour* : The modern tannery very largely employs machinery in all its processes in place of hand labour. In India, undoubtedly, so much machinery would not be of any advantage provided that skilled hand labour were available at reasonable rates. For certain kinds of work machines are absolutely essential as they turn out work far better and far cheaper than any hand labour can possibly do. But, on the other hand, in countries like America where labour is expensive, machines often supersede hand labour with a very much narrower margin of advantage and when those machines are introduced into Eastern countries where labour is cheap, the advantages, derived from their employment, entirely disappear. It would therefore seem probable that a judicious combination of machinery and hand labour would enable tanning and leather dressing to be carried on with advantage; but the difficulty is, to obtain a sufficient amount of skilled hand labour. Only the very lowest castes will do manual work in a tannery and even they as a rule only

take it up when they cannot obtain employment elsewhere. At the present time the general complaint of Madras tanners is that labour is very scarce owing to the fact that the season has been a good one and there is plenty of agricultural work to be obtained. In bad seasons labour is plentiful, but at other times it is insufficient. Practically, tanning is monopolised by poor Muhammadans and Pariahs and if any improvements are to be introduced or changes made, either these people must be educated and their intelligence developed, or a supply of labour must be obtained from other sources ; neither of which alternatives seems practicable on a large scale at the present time.

(3) The third cause which it is said would prevent successful chrome tanning in this country is the hot climate. But the evidence offered in favour of this statement is, by no means, conclusive. So far as I have been able to ascertain it is entirely based upon the fact that in America chrome tanners find it difficult to secure uniform results in the hot weather and they have had to either give up work or use artificial means for cooling their solutions. This may be perfectly true in the huge American tanneries and with the methods of working there employed and yet have no bearing whatever upon the conditions which prevail in this country. In a small way, chrome-tanned leather has been produced in India and the failure to turn out a marketable article seems to be due to defects in finishing rather than to anything inherently wrong with the tanning processes.

Even supposing that all these difficulties were successfully overcome, there yet remains the difficulty of finding a market for the finished skins. It is absolutely certain that the tariffs imposed by continental nations and by America, if not already sufficiently high to exclude Indian manufactured leather, will be immediately raised so as to prevent the possibility of finding a market in any

of these countries. The only open market is in London which is already fully supplied, and competition is practically impossible so long as foreign nations can ship their surplus productions for disposal there, at any price they will fetch. There only remains the local market in India and that at the present time is too insignificant to be of any account, though, as we shall presently see, it is in the development of the home market that the most promising results may be expected.

The export of raw skins from Madras which commenced in May 1899 is a matter of such great importance to this Presidency that it seems desirable to bring together all the statistics available and these are summarised in the following table, in which the numbers given relate to bales and in the case of pickled skins to casks.

Year.	Tanned Goat Skins.	Tanned Sheep Skins.	Raw Goat Skins.	Raw Sheep Skins.	Pickled Skins.
1898 ...	21,417	7,633	*nil*	*nil*	*nil*
1899 ...	19,903	8,042	996	...	2,347
1900 ...	19,986	10,457	3,397	257	1,730
1901 ...	12,135	9,501	6,507	404	4,312
1902 ...	12,982	8,173	5,732	280	1,540
1903 till 1st September			1,752	203	1,334

From this table it will be seen that so far chrome tanning has only affected the goat skin trade as the export of tanned sheep skins and tanned hides of all classes still remains about the same. The various brands of Madras skins are well-known in the London market and all the prime tannages, especially those prepared from slaughter-house pelts, have a high reputation and command good prices. They are chiefly used for expensive book-binding and fancy leather-work; and, although the Committee apppointed by the Society of Arts to report upon the deterioration of leather used in book-binding pronounced a very unfavour-

able verdict upon East Indian skins, yet, it does no seem to have affected their market value, and it is unlikely that chrome tanning will in any way affect the demand for these skins, as chrome-tanned leather is unsuitable for conversion into highly priced fancy leathers. The great bulk of the trade, however, is in what is known as 'up-country tannages' and as these will only take a black dye they are almost entirely employed in the boot and shoe trade and here, they come into competition directly with chrome-tanned skins. It has been established beyond doubt that chrome tanning produces a superior leather and it is, therefore, merely a matter of time before the whole of the trade in tanned goat skins except those of superior quality will disappear. So far, only trial consignments of raw sheep skins have been sent to America, and as there is a much greater difference between the freight on tanned sheep skins and dry sheep skins than there is between tanned and raw goat skins, and as the value of sheep skins is only about one-half that of goat skins, the margin to cover the cost of tanning in America is much smaller and it is therefore probable that Madras tanned sheep skins will still continue to hold their own in foreign markets.

Concurrently with the demand for raw skins there has been a certain amount of demand for pickled skins. The process of pickling involves carrying out on the skins all the processes of tanning preliminary to the immersion of the skins in the tanning pits. That is to say, the skins are unhaired and fleshed and got ready for conversion into leather, but instead of being tanned in this country they are pickled in solutions, the composition of which the several firms engaged in the trade endeavour to keep strictly secret but which are, nevertheless, pretty generally known.* If the tanning trade is doomed the

* Prof. H.R. Proctor in the Principles of Leather Manufacture, pp. 89—91.

Value in Rupees of Hides and Skins raw and manufactured exported from India and from Madras in the years 1899—1903.

	1899-00.		1900-01.		1901-02.		1902-03.	
	All India.	Madras.	All India.	Madras.	All India.	Madras.	All India.	Madras.
Raw Skins ...	1,96,24,070	16,17,018	1,72,10,710	20,00,123	2,69,65,937	59,68,643	2,51,77,192	39,45,615
Dressed Skins ...	2,66,01,037	2,00,55,198	2,90,95,058	2,14,53,836	1,84,71,359	1,36,31 098	2,19,40,294	1,68,97,997
Raw Hides ...	4,84,64,930	419	5,19,21,044	2,693	2,78,04,718	93,045	2,87,74,924	51,150
Dressed Hides ...	84,88,992	67,43,592	1,45,05,637	1,23,85,316	76,05,869	66,85,078	61,74,496	54,43,237
Total ...	10,31,79,029	2,84,16,227	11,27,32,449	3,58,41,968	8,08,47,883	2,63,77,864	8,20,66,906	2,63,37,999

export of pickled skins would be preferable to the export of dry skins as the operations involved in pickling require the employment of a considerable amount of labour and the value of the pickled skins is, therefore, somewhat greater than that of the raw skins. There seems to be, however, but little prospect of any further extension in the pickling trade and it is much more likely that it will eventually die out altogether as the majority of American tanners greatly prefer to deal with skins in the chrome baths, the previous treatment of which they are perfectly acquainted with.

From the foregoing table showing the value of the exports from India in hides and skins for the last four years for which the figures are available, it will be seen that the bulk of the Indian trade is, as it always has been, mainly in raw material, and owing to causes beyond the control of the mercantile community in this Presidency, it seems likely that there will be in the future a still greater preponderance of raw as compared with manufactured exports. In all discussions which have hitherto taken place regarding the decadence of the tanning industry in this Presidency, the home market for leather has been entirely neglected and it seems to me that this omission is one of great importance and has led to an unnecessarily gloomy view of the situation being taken. In a report which was submitted to the Government of Madras in February last, I remarked :—"It appears to me very undesirable and practically impossible that Government should take any active steps to establish a factory for either leather dressing or chrome tanning in Madras. Some years ago it was proposed to start a leather-trade school on the lines of the well-known institutions at Leeds and Bermondsey ; but as the tanners of this Presidency are practically an illiterate class of people, I fail to see that any advantage would be derived

from it, and in fact I doubt very much if any *bonâ fide* students could be induced to work in its laboratories. It has been suggested that Government should place an export duty on skins, but beyond recording the suggestion I have nothing to advance in its favour. As India enjoys no monopoly in the supply of skins it is obvious that the only effect of the duty would be to depreciate the price of skins in this Presidency and this would naturally lead to a falling off in the supply." Further enquiries made since the publication of the above mentioned report only confirm the opinion expressed therein and one is forced to the conclusion that if anything is to be done to raise the status of the Madras tanning industry, it must be in the direction of improving the manufacture of leather to be used in the country.

Whilst elaborate statistics are available concerning the export trade, practically nothing is accurately known regarding the internal trade, and it is necessary to estimate the volume of that trade by very indirect methods. From the returns of the last Census I find that in the Madras Presidency no less than 476,558 persons were dependent upon one or other of the leather trades for means of subsistence. Of these, over 100,000 males are returned as being employed in the manufacture of shoes, boots and sandals and over 45,000 males in the manufacture of water-bags, well-bags, buckets and ghee-pots. What amount of leather passes through their hands in the course of a year it is impossible to accurately estimate, but we may get some idea of the magnitude of the home industry if we assume that there are 150,000 people earning on an average of Rs. 4 a month or Rs. 72 lakhs a year. If we further assume that the value of the leather converted into manufactured goods by them is double the value of their wages we arrive at figures not far short of one and a half crores of rupees. This is probably an underestimate but it is sufficient for my pur-

pose, as all I want to show is that the home trade is by no means a negligible quantity. It is well-known that the bulk of the leather used in the country is of a very inferior quality and the consumption is much larger than would be necessary if the leather were more durable.

It seems to me, then, that any efforts to improve tanning in the South of India should first be directed to improving the supply of leather for local consumption. I propose now to only deal with one class of leather goods which, are in very large demand, namely, buckets for lifting water from wells. Probably not far short of a million hides are used every year for these articles alone. Generally, they are good hides which would command ready sale if they were available for export. The life of a leather bucket at a well is not a very long one, and, if the bucket is in use every day, does not average much more than six months and probably all through the Presidency it is always necessary to provide a new bucket for each water-lift, once a year. The buckets are made of well-tanned leather, but constant immersion in water and exposure to a hot sun cause them to deteriorate very rapidly and they are a constant source of trouble and annoyance to the ryots.

The introduction of chrome-tanned leather for these buckets promises to be a great improvement and at the risk of repeating what I have already said, I propose to quote, from "The Manufacture of Leather" by Mr. C. T. Davis, a paragraph in which he describes the characteristics of chrome leather. He says, "chrome leather has special and peculiar qualities which distinguish it from all other kinds of leather, and these special features cause it to be a superior fabric for all the purposes for which leather is used. It has often been stated that chrome leather is water-proof, but this is not a proper term to use in

connection with it: it should more properly be called non-absorbent. All kinds of leather produced with tannin absorb water readily, like a sponge, while chrome leather does not absorb water but resists it or sheds it, like the feathers of a duck. In fact, it is a difficult matter to thoroughly wet chrome leather when it is once dry. Again, water and air are the agencies in Nature which promote decomposition and decay, and as tannin and hide substance are both organic materials, and when combined, as is the case in bark tanned leather, and subjected to the process of wetting and drying, such leather will, eventually but surely, deteriorate and become rotten. Chrome leather, on the other hand, being a combination of an inorganic material with the hide substance and subjected to the same process of wetting and drying, shows no effect whatever. In fact, the oftener chrome leather is wet and dried, the softer and more flexible it becomes. Even subjecting it to boiling water apparently has no effect upon it, while any sort of leather produced with tannin and placed in boiling water is utterly destroyed. Moreover, chrome leather is of much lighter weight than bark leather and this is a decided advantage for almost all purposes for which leather is used."

Accepting this as a fair statement of the properties of chrome leather, it is evident that as compared with bark-tanned leather it is an almost ideal substance for water-bags. Chrome tanning must be introduced, or eventually, our tanning trade will largely disappear, and as we have already seen that it is practically hopeless at the present time to try and manufacture finished leathers suitable for foreign markets, it seems to me that we might well commence by endeavouring to turn out a chrome leather suitable for these water-bags. The chrome leather, at first, might not be of the highest possible quality but it would be so much better than the leather in use at the present time that

it ought to find a ready sale even at considerably enhanced prices. In this Presidency where tanning materials can be procured at extremely low prices and where the chemicals used in chrome tanning will have to be imported, it is probable that the cost of chrome tanning will always be somewhat greater than that of the tanning now in vogue. But if the material turned out is much superior and more durable, this is not likely to prove a great difficulty in the way of making chrome tanning a success. From the very outset it should be possible to produce marketable goods and, in course of time, as experience accumulates, the quality may improve and ultimately it may be found possible to manufacture leather of sufficiently high quality to enable it to be used for many other purposes. As the first step therefore in any attempt to bring Madras tanning once more on a level with that of the rest of the world, I would suggest that attention be directed to the manufacture of goods for the local market and that the manufacture of leather for water-bags promises the most successful results. The innate conservatism of the ryot may at first prejudice him against any new material, but he is so thoroughly well acquainted with the unsatisfactory character of the only leather he can at present obtain that I do not anticipate that there will be much difficulty in getting him to use chrome-tanned leather bags when their advantages have been satisfactorily demonstrated.

It would be possible to enumerate many other purposes for which chrome-tanned leather might be used with advantage in this country but at the outset I think it is desirable to limit the range of experiment as much as possible and the field opened out by the water-bag industry is quite large enough to begin with. Chrome-tanned water-bags may reasonably be expected to last two to three times as long as the ordinary bark-tanned bags now employed, and if they come into general use there is no doubt that

the consumption of hides for water-bags will be greatly reduced. This would mean a considerable saving to the ryots engaged in well-cultivation, and would throw a large number of first class hides on the market for export and will probably increase the external trade of the country by an amount which may be vaguely estimated at something over ten lakhs of rupees per annum.

The opinion is strongly held, and rightly so I think, that the best Madras bark-tanning of skins is capable of little or no improvement, but much might be done to raise the quality of the up-country tannages which at present are over-limed and far too heavily weighted with oil. The tanning of hides is carried on in much the same way as with skins. The results are not nearly so satisfactory and the buyers of East Indian kips usually re-tan them before putting them on the market. Sole leather is not produced in the Madras Presidency but large quantities are made in Bombay and Cawnpore, and there is no reason why thoroughly satisfactory sole leather should not be produced in Madras from the best quality of hides. Probably for this purpose it will be desirable to use *divi divi* which has been grown with success in various parts in India including Madras but the supply is at present precarious and steps would have to be taken to encourage the cultivation of the shrub.

With Avaram bark and Myrobalams and a properly devised process of tanning it should be possible to produce an extremely white sole leather which would meet with a large demand in Europe for the manufacture of soles for ladies' shoes and boots. These are probably the most important directions in which improvements could be made in the tanning trade of this Presidency. The actual industrial operations are almost entirely in the hands of ignorant and uneducated people and the initiative will certainly have to be taken by those who are not in immedi-

ate touch with the tanneries. The merchants and dealers, who finance the industry and export hides and skins, seem to be fairly content with the profits they are making at present and it is perhaps unfortunate for the country at large that in the financing of the raw skins, in their collection and export, as much or even more profit can be made with much less trouble than in the export of tanned skins. The lack of enterprise on the part of the educated commercial community who deal in this business is largely due to the fact that they anticipate much trouble and possibly very considerable outlay before they can introduce any successful innovations, and when the success of any new ventures seems sure they have no means of securing a monopoly of the business for even a limited time, as experience in the past has taught them that they will not be able to realise the just reward due to their enterprise. Rivals will benefit by their experience and will compete with them in their own lines and bring down the profits, which they might otherwise have expected, to the irreducible minimum. Whether any remedy can be found for this it is impossible to say but, if it could be demonstrated that the matter was of sufficient importance, it might be possible for Government to modify the existing laws in this country to such an extent as to render it possible to grant patent rights or monopolies for a limited term of years to persons introducing industries or processes which are new to India though well-known in other parts of the world. The industries of India have to face the open competition of the world, and capital is hardly likely to be largely invested in them, unless special means are taken to foster new ventures during the early stages of their working and unless privileges and rights are secured which will afford capitalists some prospect of an adequate return on their investments.*

* Reprinted from the *Indian Review* for September 1903.

HAND WEAVING*.

Of the indigenous industries of India hand weaving remains the chief, but its importance is gradually dwindling and it seems hardly likely that anything can be done to prevent it sinking into comparative insignificance. From the Census returns of 1891 it would appear that there were then upwards of nine and one-third millions, more or less, dependent upon it for a livelihood. The bulk of these people were women and children and at a guess one might set down the number of hand-looms at about two millions. Competition with the products of machine looms and a radical change in the tastes of the wealthier classes, in regard to clothing, have reduced the weavers to an extremely impoverished condition. Though to a large extent inhabitants of towns, in which educational facilities abound, they have been unable to give their children even the most elementary education, and their only means of meeting the competition, they have had to face, was by selling their labour at lower and lower rates till at length a bare subsistence is all they can command. Their appliances are extremely simple and yet with patient labour are capable of turning out products which have hitherto baffled the skill of weaving mechanicians. But the difficulty of making bordered cloths by machinery, till recently insuperable has now been overcome and it is only a question of time before the weavers of these cloths, and they form a very large proportion, if not the bulk, of the hand weaving community, will find that they have to face a keen com-

* Repr[d] from the *Indian Review*, June 1902.

petition for the market in which they have for so long enjoyed an absolute monopoly. In the long run machinery must win, if the prize is worth winning, and a trade which, in all its branches, gives employment to many hundred thousand looms is worth capturing.

The progress of the machine border loom is a danger threatening to disturb the well-being of a large section of the weaving community, but no one takes any notice of it and no one in authority makes the least attempt to ascertain the real facts of the case and warn the artizans likely to be affected. In industrial matters the rulers of India have followed too much the precedents of the West. The interests and rights of the working classes are carefully looked after in certain directions by various experts such as an Inspector of Mines, Factory Inspectors, Boiler Inspectors and so forth. But the great bulk of the artizans work by themselves or in very small associations which do not come within the purview of these expert inspectors and they are left to themselves to wallow in their ignorance and conservatism and to be gradually wiped out of existence by the pressure of imports from Europe and factory-made goods in India. In 1866 the Secretary of State for India deputed Mr. J. Forbes Watson to examine the products of the hand-looms of India and to collect information for the benefit of the power-loom weavers in England. No corresponding assistance has ever been rendered to the hand-loom weavers by the State and such changes as have taken place in their methods of working have been initiated either by the philanthropic efforts of missionaries or by private enterprise in its endeavours to foster trade. The spinning wheel has practically vanished, vegetable dyes are scarcely ever used save the now direly threatened indigo, and hand-weaving is on the decline. There is a great deal of false sentiment about much that

has been written on the decline of hand weaving and admiration for the picturesqueness and simplicity of the weaver's craft has led to neglect of the other side of the account—of the poverty and ceaseless toil of the weaver's life, of his damp and dismal workshop and of the general insanitary conditions with which he is surrounded. In truth the decline of hand-weaving is only to be regretted because of the misery and suffering which millions must endure owing to the loss of their livelihood, poor as it is, and their utter inability to take up any new industrial occupation. The problem presented by the weavers is in truth a very serious one and we propose to briefly discuss what measures may be taken by the State to help this section of the artizan community over their difficulties.

In the full belief, that in a purely mechanical operation like weaving, the machine must ultimately triumph over the hand-loom, no matter how cheap may be the labour of the worker, all that we can hope to suggest are palliative measures by which the period of transition may be bridged without any violent industrial dislocation. First and foremost we should place at the weaver's disposal the best technical skill available to enable him to improve his methods of production and thus enable him to hold out for a longer period against the inroads of machine-made goods in his markets. Secondly instead of leaving him to the mercy of the middlemen he should be given assistance in commercial matters and as far as possible the producer should be placed in direct communication with the purchaser. Lastly special attention should be devoted to the education of the community so as to enable them to avail themselves of other outlets for their energies.

It will be convenient to discuss these suggestions at length and to deal with them in the order given. Practically the first suggestion amounts to stating that facilities for industrial or

technical education should be provided for hand-weavers. At the outset we may frankly admit that there is probably not in the country any one capable of stating what can be done to help the weaver. If we knew how to proceed the matter would be comparatively simple and would resolve itself mainly into a question of providing funds. It is easy enough to obtain the assistance of expert weavers from outside but they are not acquainted with the weaving problem as it is presented here and though they might give valuable advice yet they can do nothing more than indicate the general lines upon which experiments may be conducted. The weavers are exceedingly poor and in the main rely on middlemen for the small amount of capital actually employed in their trade—they are ignorant and narrow-minded and averse to enquiries regarding the detail of their trade. Each man works for himself and there is little or no co-operation among them. There is no chance that any weaver may arise with an intimate knowledge of the technique of the trade and with a mind sufficiently wide to grasp the general trend of the economic forces which are gradually driving his fellow castemen to misery and despair. The only hope lies in the conduct of experimental weaving by the State with the object of working out by degrees a better system of production. This course we have embarked upon in the School of Arts, Madras, and we have established a weaving shed for the purpose of ascertaining by experiment what can be done. For about a year work has been in progress and without entering into minute technical details it is proposed to briefly state what are the tentative conclusions arrived at. These are that the native method of preparing the yarn for the loom is extremely laborious and very defective and that in consequence the outturn of the looms is much smaller than it would be if a better system were in vogue—that the native loom is capable of

improvement at small expense by a slight modification of the slay whereby a "flying shuttle" can be used. To this, however, an exception must be made in respect to "bordered cloths" and so far, for this class of goods, it must be confessed that no practical improvements have suggested themselves. The introduction of the "flying shuttle" converts the native hand-loom into a European hand-loom and the more perfect the conversion the better is the result. A self-contained frame loom can be made for about Rs. 60 and with expert weavers there is no doubt that the outturn of cloth can be doubled provided the warp is good. This is an important proviso because the warp as ordinarily prepared by native methods is not good enough. Native warps are not sufficiently well-sized, they are not long enough and the threads are not perfectly parallel to one another. In the native hand-loom these defects are not so obvious, but directly the fly shuttle is used the weaver's troubles begin and more than half his time is spent in mending threads. By great care in the preparation of warps these difficulties have been to some extent got over but the extra expenditure on the warps counterbalances the saving on the loom. In the School of Arts weaving shed, we have come to the conclusion that some system of warping machinery of the type that is in use in power weaving sheds is necessary but at present no system that has been examined meets the requirements of the case. The crux of the whole matter appears to be "sizing" and nothing but the "slasher" sizing machine seems suitable. Yet it cannot be adopted because it is too big for the business required of it. One machine would easily supply 1,000 looms and the time has not yet arrived when it would be possible to set up so large a hand weaving factory. It is thought that, at the most, factories or associations of 100 hand-looms could be formed and the problem is to obtain a warping mill and sizing

machine that will turn out from 1,000 to 2,000 yards of warp a day. Hand-power is probably all that can be counted upon and the drying of the warps after sizing must be done without the aid of steam. Investigations are in progress with hank sizing* and it is hoped that ultimately they may prove sufficiently satisfactory for practical purposes in which case the rest is easy. If success is attained in this direction it will be possible to provide buildings and plant for preparing warps at a cost of about Rs. 9,000 which will supply from 100 to 150 looms and such looms working with these warps may be expected to turn out twice as much cloth a corresponding number of native looms. Assuming then that hank sizing is a solution of the difficulty a simple calculation shows us that a capital outlay of Rs. 150 per loom will enable double the output to be obtained. The total cost of preparing warps with machinery will probably not be reduced but better warps will be obtained and the advantages of the fly shuttle loom will have to pay for the capital employed and provide better wages for the weaver. At the present time the weaver does not earn more than As. 4 per day and if his output were doubled he would get, other things remaining the same, As. 8 per day. Of this we may allow him As. 6 and take As. 2 for interest on his capital, depreciation of his plant and so forth. As. 2 per day may be taken as Rs. 30 a year or Rs. 3000 for 100 looms involving a total capital outlay of say Rs. 15,000 made up as follows:—

Warping and sizing machinery Rs. 5000.

100 looms at Rs. 60 each Rs. 6,000.

* Hank Sizing is now invariably employed in the experimental weaving shed in the School of Arts, and is quite satisfactory. The improvement of the warping machinery has however been delayed pending orders from the Government of India as to the desirability of continuing these experiments in Madras

Shed for warping mill, godowns and offices Rs. 4000.

The weaver it will be seen is still supposed to work in his own house and where no weavers can be got within a reasonable distance it would seem possible that a capital outlay of Rs. 150 per loom would find a remunerative return. If these results can be obtained in practice, and it is the ultimate object of the experimental work at the School of Arts to demonstrate that they can be accomplished, the question of raising the capital should not prove insuperable. Should the comparatively simple system of hank sizing prove unsatisfactory and should it not be possible to devise any simple equivalent then we shall have to fall back upon the slasher sizing machine with its much greater cost and much greater output and instead of dealing with groups of 100 weavers we may have to attempt the problem of starting hand-weaving factories on a very much larger scale and with consequently much greater risks and a much more expensive system of control. The weavers of bordered cloths are entirely outside any such scheme as outlined above and enquiries indicate that between the methods they now employ and the highly complex machine border loom there is no intermediate stage. The more intricate and difficult the weaving process and the longer the time it occupies, the less important becomes the preliminary work of warping and dressing, and consequently the smaller is the scope for improvement in the trade as a whole.

Dealing now with the second suggested line along which assistance may be rendered to the hand-weaver it becomes obvious at the outset that the association of weavers in groups of 100 or more all deriving their warps from a central warping mill totally changes the conditions under which the trade would be carried on. It will not be difficult to imagine that the capitalist who sets up the dressing machinery will purchase the yarn, supply warps

to the weavers, take back the finished goods and dispose of them to the market. He will be able to buy yarn in large quantities on favourable terms and obtain it from the spinning mills in suitable forms for his preliminary operations and will be able to introduce minor economies that in the long run become important. The management will have to possess business knowledge and acumen and will therefore be in a position to ascertain what goods are most likely at any given time to be in profitable demand. From the weaver's point of view the difficulty will be to prevent the warping mill owners from sweating their dependent weavers and to secure that a fair share of the profits falls to the lot of the weaver. So far as one can foresee the proposed changes will throw out of employment the vast mass of the women and children who now perform the greater part of the preliminary work. There will be still work for some of them and each weaver will find one assistant at the loom useful to mend occasional broken threads and perform a variety of small operations which would otherwise take up a considerable part of the weaver's time. Women work hand-looms in most countries, in the future they may perhaps do so in India. At any rate none can gainsay the fact that it would be an immense advantage to the weaving community if their women and children were in the main relieved from the drudgery of industrial work and thus the women better enabled to attend to their domestic duties and the children in a position to avail themselves of such educational advantages as may be within their reach. The Indian hand-loom has made a prolonged struggle against machinery and there is but little doubt that there will always be a limited field in which it can complete on level terms with machinery. Probably any weaving operation can be carried out in a power loom if the machine can be given a sufficiently long run of work but it is not always feasible to provide enough work of a certain kind to make

the business commercially profitable and such work naturally falls to hand-loom weavers. It is very desirable that there should be instituted some kind of association of weavers and that funds should be subscribed to be devoted to making commercial enquiries, to diffusing useful trade information, to opening new markets and generally supplying the ignorant hand weavers, through say the managers of their warping mills, with all such information relating to their trade as will enable them to keep abreast of the times. In the first instance there is no doubt that Government would have to initiate the organization and supply the necessary funds but if it proved of real assistance to the trade it would probably soon become self-supporting.

Lastly we come to the question of educating the weaving community, and this we regard as of great importance, for in the first place it is almost inevitable that a great proportion of the weaving castes will have to abandon their hereditary calling and seek a livelihood in other pursuits. It requires no demonstration to accept the statement that the better educated they are the better they will be able to take care of themselves and the less they will be dependent on the State. And secondly assuming that the schemes just outlined prove practicable and the weaving community is reorganized on a modified factory system it will require a more intelligent class of men at the looms to make it a complete success and in no way can we raise the standard of intelligence but by diffusing education amongst them.

The wages of the weaver have sunk to the lowest limit compatible with earning a livelihood because the community as a whole are ignorant and unintelligent. No new processes will better them unless in the working of them greater skill and more intelligence is required. Cloth may become cheaper, the outturn of the weaver may be greater but his position will be unchanged.

This is but natural since whatever changes are effected he has no hand in them and consequently no claim to be rewarded. If new processes demand greater skill and intelligence it is but a common place to observe that for these qualities payment must be made. Herein we think is the root of the whole matter—if hand weavers are to be put in a better position their trade must be put on a higher level and in its operations there must be a demand for more skill and more intelligence than is necessary at present.

MANUAL TRAINING.*

In addressing the members of the Teachers' Guild of Madras on the subject of Manual Training it appears to me unnecessary that I should occupy your time with a history of the movement in other lands, or with a *resume* of the discussions, which have been in progress for the last quarter of a century, on the position which should be assigned to Hand and Eye culture in a general scheme of education. It will suffice to say that, in the changed conditions of modern times, a purely literary education has been generally recognized as an inadequate means of developing the latent powers of the mind, and of stimulating into vigorous activity those faculties which are most frequently exercised in the exigencies of ordinary practical life. A revolution in pedagogic methods has swept over the world and a classical training is no longer deemed the only, or the best, preparation for the great majority of people, who have to look to scientific, commercial or industrial pursuits for a subsequent career. The enormous extension of the bounds of human knowledge and the marvellous increase in the facilities for transportation has rendered the struggle for existence intense in the highest degree, and has compelled us to abandon all Platonic notions of education and to adopt as subjects of instruction those which will not only develop the intellect but which will also be of material use afterwards. The study of languages, literature, history, mathematics and philosophy leads possibly to the highest forms of mental culture, but not to all, and it leaves many of those

* Read at a Meeting of the Teachers' Guild, Madras, August 1896.

faculties, which are of the greatest importance in everyday life, untrained and neglected. Fortunately, the processes of education are not confined to the teaching of schools and universities, but are largely carried on, unsystematically and insensibly perhaps, in the play-grounds and in the homes of children, and later in life by the experience acquired by contact with a busy and unsympathetic world. The general result is fairly satisfactory and the defects of the scholastic training are to a certain extent remedied, but much valuable time is lost and much trouble is caused which might have been avoided, if education had from the outset been conducted on lines which brought it into intimate contact with the necessities of our daily existence.

Probably the most important difference between old and new methods of education lies in the recognition which the latter has accorded to the necessity for manual training, and the provision which it has made for the cultivation of those faculties which depend on other than purely mental processes for their proper development. It would have been an interesting and not unprofitable task to have described to you what has been done in Europe and America in this respect, but our time is limited, and nearly all that I could have told you is to be found set forth in great detail in numerous and readily accessible publications, which have appeared in recent years, and I therefore propose to confine myself this evening to the purely Indian side of the question which is, after all, that in which you are most interested.

In Madras the University is the centre of higher education, and exercises a virtual control over it by the courses of study which it prescribes for those who wish to obtain its B.A. degree. Though I have no wish to under-estimate the efforts which have been made to promote the study of physical and experimental science, I think I am justified in saying that, in the main, the

possession of a university degree indicates that the holder has received a literary training. For the administration of the country, for the conduct of its legal business, for the development of education and for numerous minor services there was for many years a demand for graduates, which was in excess of the supply, and the market value of a university degree was high, but year by year the supply has increased, whilst the demand has remained practically stationary, till at the present time the young graduate has often to start life on wages less than a good artizan can earn.

Twelve years ago the late Mr. Grigg who was then the Director of Public Instruction in Madras wrote "there is a growing feeling that the literary market is overstocked, and consequently that if educated men, Hindus especially, are to obtain a provision for life, they must turn their attention to non-literary branches of knowledge." For this reason technical education has been encouraged and greatly increased facilities provided for the study of applied science. Judged from the mere stand-point of numbers, the measures which have been taken in this direction have met with considerable success, but those, who are in a position to pronounce an opinion on the quality of the work done, are compelled to admit that it is far from satisfactory, and are generally agreed that it is so, because the students lack those mental qualities, which elsewhere, it has been discovered, can best be cultivated by thorough and systematic manual training. That this result was to some extent anticipated, is evident from the fact that the educational authorities in this Presidency nearly ten years ago recognized the desirability of introducing manual training into High Schools and Colleges, and the Managers of a number of these institutions were persuaded to open carpentry classes, at which attendance was voluntary; but presumably on account of

the expense involved, and the entire absence of suitable teachers, no attempt was made to introduce an organized system of working, and no immediate results being apparent, most of the classes were soon closed, and at the present time only two or three in the Northern Circars are still maintained. In the first-grade colleges, where the natural sciences are taught, the laboratory work affords a certain amount of manual training, but it is commenced too late in student life to be of much value and there is no doubt that the inaptitude for experimental work, which is only too apparent, is in the main due to want of previous training.

Educated people of this country are singularly deficient in powers of observation and evince a fatal readiness to accept statements of facts, without any attempt at verification for their own satisfaction, which renders them incapable of achieving marked success in practical matters. This is partly due to inherited tendencies and to the simple nature of their surrounding in early life, but is probably still more largely due to the bent which their minds have received by the purely bookish studies of their school days.

So far as I am aware the only institution, which is not an industrial school, in which manual training forms an important part of the work of the students, is the College of Engineering, where it has been found of great value in counteracting the effect of this early training and in introducing them to the region of things and realities in which they have elected to work. It is a radical change in methods of study and modes of acquiring information which they encounter, but the change is effected too late for the highest results to be obtained, and there is no doubt that if they came to us with the manual skill and dexterity they now acquire before leaving, and with all those faculties cultivated, which the possession of manual skill and dexterity denotes, we

should be able to produce quite a different stamp of engineer, and our students would soon wipe out the stigma which attaches to native engineers, on account of their deficiency in resource, want of originality and inability to sustain the heavy responsibility, which great engineering works always entail on those in charge of them.

Although there are no schools in this Presidency in which a manual training is avowedly given, there are certain philanthropic institutions for the education of European and Eurasian boys in which industrial work is carried on in the hope that the boys may be able to acquire sufficient knowledge of a trade, to be able to earn their own living by working at the trade, when they leave school. Quite recently, I have inspected several of these schools and my attention has been forcibly drawn to the fact, that the original object has not been achieved, and the opinion I have long entertained, that it is not possible for European and Eurasian lads to make a respectable living in competition with the ordinary native artizans, is fully confirmed. I find from an examination of the registers of past pupils that the boys when they leave, seldom follow the trade they have learned in the school unless under exceptionally favourable circumstances, in which it is evident that their knowledge of English, and their ability to read and write have been important factors in determining their selection for employment as artizans at remunerative wages, and in fact that the so-called industrial departments have, by force of circumstances, become manual training schools, in which, however, there is much that requires to be improved. To some extent this is admitted by those connected with the management of these institutions, but it would be better if they would openly acknowledge the fact that the main use of the workshops is to develop the boys' brains, and make them handy and dexterous,

so that they can take an active and intelligent interest in whatever work they may chance to be engaged on, thus becoming useful members of society and able to learn a living in a great variety of ways. It would then be desirable to re-model these schools, to introduce courses of practical work, better calculated to attain the avowed end, and to abandon the teaching of such trades as tailoring and bootmaking, which are not well adapted to develop either mind or body, but which at present are favourite trades, because the boys can be profitably employed in making their own clothes, and because they do not entail too much physical exertion on the unfortunately by no means small number of boys, who are in weak health or deficient in bodily strength. At the same time I would suggest an improvement in the general education given to these boys, so that they may be sent out into the world better equipped, than they are at present, to combat with the peculiarly unfortunate and difficult circumstances in which they are placed.

Although it does not strictly fall within the limits of my subject this evening, I cannot altogether avoid alluding to the Industrial Schools, pure and simple, of which there are a considerable number in existence, if only to point out the essential difference between their objects and the methods by which they may be attained, and those of the advocates of the introduction of manual training into schools solely on account of its educational value. The Industrial school is intended to be a substitute for the system of apprenticeship, and it has been tried in many countries and under varied conditions, but has seldom been found to work satisfactorily. In it, you undertake to teach a trade better and quicker than it can be taught in the ordinary workshop, where it is carried on for commercial reasons, and there is no doubt that in many instances it is possible to do so, when unfettered by

pecuniary considerations, but unfortunately these are nearly always dominant factors, and it is now generally agreed that, only under a peculiar and usually not permanent condition of things, there is any advantage in establishing such schools.

In India, at the present time, the indigenous trades are practically in the hands of certain castes, each of which enjoys the monopoly of a trade, and its members form a very exclusive trades union. The system is a great evil, as it prevents competition and restricts progress, and there is a wide field for industrial schools in breaking down these artificial restraints and raising the standard of skill. So far, however, those that have been established have not met with any great amount of success, owing chiefly to the difficulties which surrounded their inception through lack of experience on the part of the Managers, insufficient funds to properly carry on the work and an entire absence of suitable instructors. Progress, nevertheless, has been made and the future prospects of several schools are very promising.

To quote from the last report on Public Instruction in this Presidency "the aim of manual training is not to afford instruction in a trade. The constant repetition of some single operation with the view of acquiring mechanical dexterity, is the business of a trade school. To go through a systematic course of hand work purposely designed to bring into play some faculty of the mind and to form some intellectual or moral habit, is the true function of manual training. Manual training does not seek to turn out carpenters or blacksmiths or fitters, but to educate the hand and eye, to form habits of observation, judgment and accuracy, to cultivate the sense of proportion, to make the pupil ready, resourceful and self-reliant." The failure of the carpentry classes, already alluded to, is accounted for by Dr. Duncan, in the same report, in the follwing terms: "the reason for their

almost total disappearance is that they were afflicted from the first with the inherent weakness that they were taught by the ordinary bazaar artizan or maistry instead of by a trained teacher. Besides the fact that such an instructor was skilled only in the antiquated ways of doing things, there was the further drawback that he could only instruct by example. Young people like to understand the reasons for the various processes and not merely to have the processes shown them. But the ordinary artizan is himself unacquainted with principles, and is therefore quite unable to explain why one way of doing a thing is better than another. It consequently, soon came to be seen that the cost of maintenance was incommensurable with the small amount of benefit received."

For the industrial school, the instructor should be a highly skilled artizan, with a practical knowledge of the most modern processes employed in his trade, able to draw, to sketch and to work from drawings and competent not merely to work with his own hand, but also to explain in an intelligent manner to others how and why he does a thing in a particular way; whilst in a school, where manual training forms part of the process of education, it seems to me unnecessary for the instructor to be a trade expert but rather that he should be a trained pedagogue, who has made a special study of some branch of manual work, just as one of his colleagues might have taken up mathematics and another English literature. Of course, to be a successful teacher, he must take more than ordinary interest in the work and the natural bent of his mind must be towards mechanical matters, but it is no *sine qua non* that he should have devoted years to acquiring the skill and perfect manipulation which characterizes the best workmen. If working in wood be the particular form of handicraft taught, and there is none more suitable, the instructor should be fully acquainted

with the principles underlying the action of each cutting tool and should possess the knack of readily explaining abstruse or intricate points with neat sketches and suitable illustrations. With the proper use and correct handling of each tool he should be familiar and, though he may be by no means a first-rate carpenter, he should be able to teach a boy to make a wooden box or carve a model yacht just as well as he could teach the Elements of Euclid or simple equations though his knowledge of mathematics may not extend to Co-ordinate Geometry or the Differential Calculus.

If manual training is to form part of the course of instruction in our schools and if one of the objects, which is to be accomplished thereby, be to implant in the minds of the youth of this country the idea that labour with the hands is equally elevating and dignified as is purely mental work, I do not think the schoolmaster will be successful if he has to confess that it formed no part of his own education, and that he has perforce to hand his pupils over to an uneducated artizan under whose tuition, if it can be so termed, the real end for which the work is imposed will be almost entirely lost.

The first step, therefore, towards the introduction of manual training must be the provision of suitable teachers. Either we must educate selected artizans till they are fit to be instructors, or we must make manual work a voluntary part of the course of training in such institutions as the Teachers' College. It will be no use to attempt to force such work on students of the age they are at Saidapet, as they are too old and the time available for training them is too short, to make it worth while to do so unless they are keenly interested and exceedingly anxious to make the most of their opportunities. The difficulties in the way of either alternative are very real and progress at the outset must be slow

and unsatisfactory. The mental capacity of the artizan classes is very limited, except along special lines, and the castes, to which the great bulk of the educated people belong, are by nature indolent and disinclined to physical exertion. In other countries there has been a demand for manual training, in India there is apparently none and probably never will be, till it has been clearly demonstrated that time spent in the acquisition of manual skill is as likely to directly lead to success in after life, as is the time now spent in preparing for University or Government examinations.

In Europe and America the schools, which have added manual training to their curriculum, have as a rule provided what according to Indian ideas would be considered elaborately equipped workshops, and each boy goes through a carefully arranged course of work, specially designed to achieve the object in view with the minimum expenditure of time and material. It will be a long time ere in Madras, I fear, we shall be able to incur, in more than a few isolated instances the expense of setting up even the simplest and cheapest type of workshop, of the style that has been adopted in the poorest of Western countries, and either things must remain as they are, or we must at first be contented with something less perfect than the systems which have found favour among richer nations.

At the outset our resources and energies must be mainly devoted to providing teachers, not specialists remember, but men who, in addition to the work they now ordinarily do, should be able to superintend, possibly at first with the assistance of trained artizans, workshops in which the boys would be taught various simple kinds of manual work. Of trained teachers there is no lack, and the question is, can they now acquire the necessary special knowledge and skill that are required to fit them for conducting manual training classes. To this, undoubtedly an affirmative answer

can be given though it is probable that the teachers will find the task the more arduous the later in life they take to it. Assuming this, and making the further assumption that there is a desire on the part of some teachers to qualify themselves, we may enquire what facilities exist to enable them to carry out their wish. For this purpose it would be perfectly feasible to make use of the plant and equipment which is already installed in the College of Engineering and in the various industrial schools, which are scattered over the Presidency, either during those hours of the day when the workshops are not used, or during vacations and holiday times when no work at all is going on. Speaking entirely on my own responsibility and without having consulted those higher authorities before whom any such proposals would have to be brought, I see no reason why during the hot weather months of May, June and possibly July the workshops of the College of Engineering should not be available for training teachers at a comparatively trivial expense, either on the lines we have adopted for our own students or on a form of Sloyd system modified, as it could easily be done, to suit Indian requirements. A course of manual work, lasting from 6 to 10 weeks each hot weather and spread over two or three years, would be I think regarded as an interesting recreation and an agreeable change from the monotony of school work, rather than as an additional burden on the shoulders of the possibly somewhat hard worked schoolmaster. In the intervals between each period of training much might be done by the teachers, in their homes or schools to keep up the skill that has already been acquired and to improve upon it, with comparatively simple means and with an expenditure on tools and materials that would not be serious.

In the College of Engineering we follow very closely the system of manual training which I first saw in operation in the

Finsbury Technical College, and which is wider and more varied than the Sloyd or other continental systems, which are adapted for children rather than for young men. Our course of instruction may be divided conveniently into three sections, (1) Carpentry, (2) Fitters' work, (3) Machine tool work.

At Carpentry the students usually begin with the saw and plane and are at a very early period set to construct a wooden box, which necessitates making the acquaintance of most of the commoner tools, after which follow exercises in tenoning, which introduce them to the various forms of chisel. Then follows a series of exercises on the different forms of joints employed in wood work which, if satisfactorily executed, indicate that the student has acquired a fair amount of skill and is fit to be entrusted with work in which he has to deal with material of some value and that he is not likely to spoil it. As far as possible we use soft woods, such as white fir, which we get from old packing cases, or white cedar and red cedar from the West Coast and teak and other fairly hard woods, are only used when a certain amount of facility in handling tools has been acquired. Wood turning is practised to some extent but as a rule time does not permit of much being done.

At fitters' work a start is made with the hammer and cold chisel and the first exercise is to chip a surface of cast iron fairly smooth, and then to file it quite flat and true to an ordinary square. This is by no means easy and generally takes a long time to accomplish satisfactorily. The third and fourth exercises are a repetition of the first two, the material used being wrought instead of cast iron, and the final product a rectangular block or cube, in making which the callipers, marking out table and scribing block are first used and the student obtains some idea of the precision and accuracy with which it is possible to work in metals.

At this stage the student begins lathe work and from a rough forging has to turn a one-inch bolt and cut a screw on the shank, either in the lathe or with dies, tap the nut to fit it, and file up the nut and head of the bolt so as to form in outline regular hexagons and finally finish them off in the lathe to the conventional form. The next piece of work is one which takes a long time and may be regarded as the last of the exercises which have to be gone through as a preliminary to being set on the construction of tools or machines. It is to prepare a true surface of cast iron to a Whitworth standard surface plate. For this purpose a rectangular plate of cast iron 9 inches long and 6 inches wide and about $\frac{3}{4}$ths of an inch thick, with deep heavy ribs, on the back is supplied. The tablets at the ends are chipped and filed flat, holes are bored and tapped and wrought iron handles are turned in the lathe and screwed in. The edges of the plate are chipped and field square with the top, and dressed so as to leave the upper surface an exact rectangle. The plate is then fixed in the planing machine and the outside skin removed and a fine finishing cut taken, so as to leave every part of the top as nearly as possible in the same mathematical plane. That it is however far from perfection the student soon discovers when, after having lightly filed out the tool marks, he proceeds to test it on the standard surface. Into the details of the subsequent process of scraping it true, I cannot now enter but I may tell you that is a very laborious operation and requires the exercise of a vast amount of care and patience to successfully accomplish. The result, however, is worth the trouble, as it is the finest work a fitter can do, and as the plate is a copy of a standard surface it is a valuable addition to the workshop tools. From this stage onwards the student is generally employed on whatever iron work may be going on in the shop, such as the making of lathes or small

launch engines, attachments to existing tools or the preparation of specimens for the testing machine, and the work is generally so arranged that he shall be able to gain experience in the working of all the machine tools and in the modes of marking out, setting up and fixing articles which require machining.

At the time he leaves the college he is by no means a good workman but he is on the way towards becoming one, and he has learned what work means and the care, skill and intelligence that are required to produce good work. The originators of Sloyd, as a means of education, have made a great many experiments on various forms of manual work and have come to the conclusion, which they are putting into practice, that wood Sloyd alone is not only sufficient for the ends they have in view, but that in every way it is better adapted to accomplish them than any other form of hand labour. They have introduced manual training at an earlier educational period than is done in the schools of England and America and its character is mainly determined by that fact. Wood Sloyd is preférable on account of the possibility of doing accurate work which is not the case with rattan work. tailoring or even blacksmiths' work, whilst fitting as I have just described it to you, although it permits of even greater accuracy in its execution, is too dirty, involves too much hard work and occupies too much time to form part of a school training. This is all quite true and I am fully of opinion that in this country carpentry or wood Sloyd is amply sufficient and can most easily be taken up, but for our own particular requirements in the College of Engineering, it is inferior in some respects to fitters' work. The latter is dirty and it is well that engineers should not be afraid of dirt, it requires greater care and imposes more reponsibility than wood working and above all

things it more frequently calls for the exercise of dogged perseverance and hard manual work which develops those qualities which are most essential to success in the engineering profession. For these reasons, and for others which do not now concern us, we have adopted fitters' work rather than carpentry for the manual training of our students.

I have dwelt at what you may perhaps consider undue length, on the work and methods of the College of Engineering because I have felt that it is desirable that you should understand why we have made a speciality of manual training, and how through a wise liberality on the part of Government we have been able to provide facilities for it equal to those possessed by any Institution in any part of the world. Considering the limited resources at the command of the educational authorities I think it is a pity that these workshops should ever be standing still, and I have no doubt that if the members of the Teachers' Guild express any strong desire for special courses of instruction in manual training, the Director of Public Instruction will, when he learns that it is possible, do his best to give effect to your wishes. I have mentioned also that the workshops of industrial schools could be made available as they are seldom used during the whole day and the benches and tools would suffer no harm if used by persons desirous of going through a course of manual training. Instruction of the proper kind you would probably have to do without to a large extent, but with the help of books and an occasional hint or demonstration from the artizans in charge of the workshops, you could do much and there is no doubt that if in the end you succeeded, the very difficulties you would have overcome would have materially increased the benefit you will derive from such work.

Passing from the question of how it is possible, in the course of a few years, to provide a fair number of teachers, capable of

giving instruction in manual work, to that of making use of them afterwards I feel that I am not altogether on as certain ground as I was before. With the manual training of persons whose school days are over we have had some experience in India, but with those of younger age none at all and any remarks which I can offer must be of a very general nature.

Dr. Woldemar Goetze, an eminent German Educationalist, says, "Manual training is an extension of the means hitherto employed for the education of the young: it seeks to utilise a child's innate desire of activity to the developing of its bodily and mental powers by systematic exercise." But here in India I am doubtful if children are as active and restless as they are in more temperate climates and if they will take so kindly to a regularly prepared programme of manual work. The advocates of Sloyd maintain that unlike other subjects of study it is "enjoyed on account of its own intrinsic merits and need no extraordinary incentives to urge the scholar to pursue it." Without experience it is impossible to say how Indian children would take to manual work—it is practically certain that they do not exhibit the same eagerness to be always making something which is characteristic of European children, which feature undoubtedly is at the bottom of the pedagogic success of Sloyd and other methods of manual training.

It will therefore be necessary at the outset to make the work interesting, extremely simple and to involve comparatively little physical exertion. Probably the best way to ultimate success will be to begin with occupations for the training of the fingers, such as card board work, paper weaving and string work, combined with freehand and simple geometrical drawing and modelling in clay. None of these forms of manual work involve much expense for apparatus or materials, and graduated exercises

in each have been most carefully prepared and published in England, with illustrations and full instructions, so that there will be no preliminary difficulty in arranging a suitable course of work. Intermediate between these elementary forms of manual work and wood Sloyd or carpentry comes fretwork, which is by no means to be despised, especially, if the boy is encouraged or made to draw out his own patterns, and it might I think well serve as an introduction to wood work.

Swedish wood Sloyd or English modifications of it are unsuitable for India and it would be undoubtedly necessary, if the Sloyd principles of teaching were adopted in their entirety, to design an almost entirely new set of models. The advantages of Sloyd, however, mainly if not entirely, depend on the efficiency of the teacher and with a bad teacher the undoubted merit of the graduated series of exercises, which are provided in the High School series of Models of wood Sloyd, is to a large extent lost and any series of exercises would do nearly as well. Students in this country are so utterly deficient in manual skill that not one per cent. can handle a penknife or sharpen a pencil properly, and under such conditions it really matters little at first what system of manual training be adopted, so long as something is done. Any of the courses, which have been worked out at Nääs, Berlin, Leipsic, Osnabrück, Strassburg, Vienna or St. Louis, could be adapted to Indian requirements, though those, which allow of the production of objects of utility from the beginning, are undoubtedly better suited to the poverty of the country and the ideas of the people. The Sloyd principle, that the articles made should be the property of the boy who makes them, is an excellent one and no idea of selling the productions of a manual training class should be entertained at any time, though there is little or no objection to enlisting the services of the older boys in

the manufacture of articles, whether furniture, models or apparatus for the school use.

To confine manual training to wood work, as is now done in Sloyd, seems to be setting unnecessary limitations on the usefulness of the course and it would be preferable out here to give instruction in metal plate work, possibly not so much for educational as utilitarian reasons. Manual training and elementary science teaching should be much more intimately associated than has hitherto been done in any school that I know of, and for this reason, if for no other, it appears to me desirable that boys should learn metal plate work, so as to be able to make simple articles out of bent wire and tin plate, and then they will be able to manufacture nearly all the apparatus required for elementary experimental science at a surprisingly small cost. To show what can be done in this direction I have lately had a few things made in my own workshop, which I have brought here this evening and I think you will agree with me, after inspecting them, that there is nothing in these models and machines which could not be made at a very small expense by persons of but slight manual skill, and that for practical purposes they are just as good as the elaborate costly apparatus which it is usual to import from home.

Then again, in another direction, the introduction of manual training would enable boys to make things for their own amusement, and it would be well I think to encourage them to do so. As illustrations of what I mean I have brought one or two examples which I have had lately made. In the most rudimentary type of lathe the turning of these peg tops is not a difficult matter, whilst a very little ingenuity is required to make these draughtsmen. The construction of a chessboard of dark wood with the alternate squares inlaid with wood of a lighter colour is a nice piece of simple carpentry. Chessmen are a little more

difficult than draughtsmen but not beyond the scope of the boys who have been taught to use their hands. Cricket stumps and bails are easily made, but I am sorry that to make satisfactory bats is beyond the skill of any but specialists and moreover in this country it is impossible to obtain suitable wood. As a last example let me bring this model yacht to your notice. Model yachting is a sport which has not been introduced into this Presidency, though it possesses many alluring features and during at any rate part of the year there is an abundance of small tanks and ponds which are suitable for sailing these small craft on. As an exercise in manual training no other example, that I am acquainted with, offers so much scope for the display of a wide range of knowledge of practical matters, and for the cultivation of a sense of form and beauty and for the development of originality, for so small an expenditure of materials as the carving or building of a model yacht from properly prepared plans. The drawings which must be first made are excellent pieces of projection, then templates should be made to the curved lines, suitable timber selected and marked out. In small boats a knife may be freely and conveniently used for the external carving, and a gouge for cutting out the interior. The fitting of the deck and the adjustment of the keel are pieces of work which offer opportunities for the display of ingenuity and skill, whilst the work connected with the sails, rigging and steering gear requires general handiness in a variety of ways and demands experiment and observation and frequently considerable modification of the original plans before the best results can be obtained.

In conclusion let me briefly indicate the points which I think may be most profitably taken up in your discussion of the remarks I have addressed to you this evening. Let us assume

that our present system of education, though it possesses many good points, is admittedly imperfect and that it does not produce the stamp of man that is required at the present day outside certain narrow circles, admittance into which is gradually becoming more and more difficult. The introduction of manual training I have suggested as a remedy, which Western nations have found efficacious under similar circumstances and I ask you to seriously consider whether or not it is applicable to this Presidency, whether the defects in the character of the modern educated Hindus are due to the unpractical nature of their education, or whether they are racial and only to be removed by a process of evolution which will take generations to effect. If you answer that manual training will do much, then I ask you to consider the great difficulties that have to be faced, and the action that the Teachers' Guild as a Society may take to overcome them, and the duty that lies upon each of you as individuals, who have chosen the teaching profession for a career and are therefore morally responsible that every effort, that can be made, is made to give the children of this land the education that will best fit them for their work in the future.

INDUSTRIAL EDUCATION

Your Secretary was kind enough to invite me to contribute to the proceedings of this Conference a paper on Technical Education, but the term is such a vague one and in its widest and most accurate sense embraces such a vast field of educational labour that I felt compelled to ask permission to be allowed to limit the scope of my remarks to one phase of the question and even with the restrictions that I myself have imposed it seems hopeless in a single paper to try to put before you at all a clear view of the problems presented by Industrial Education in India. In Madras one set of solutions may be found practicable, in Bombay another, whilst in Bengal a third may be better suited to deal with the local situation. I therefore think that we shall be able to spend our time this afternoon more profitably and elicit a more practical discussion if I confine myself to the leading features of the problem as presented in our own Presidency, and though much of what I shall have to say my be applicable to other parts of India, yet at the outset I should like to state that the case as I shall present it to you and the suggestions which I shall have to make are intended, in the first instance, to apply to the Madras Presidency and only so far as local conditions are similar to other parts of India. At the beginning of the twentieth century the industrial position of the Madras Presidency is one which it would be difficult to paint in roseate hues, yet it can hardly be considered very grave, and there are hopeful features about it which I am

* Read at a Meeting of the Teachers' Guild, Madras, December 1901.

sanguine enough to think can be effectively developed if only a working plan can be devised and carried out on a scale adequate to the magnitude of the interests involved.

Just a hundred years ago the *Pax Brittanica* was established and through the whole period since then law and order have prevailed and life and property have been secured. Population has increased at a marvellously rapid rate and long since the food supply would have proved insufficient but for the magnificent operations of the engineers both in the Irrigation and Railway branches of that profession. Millions of acres have been supplied with fertilizing water and thousands of miles of railway provide means of transport. Seasons are no better, perhaps worse than formerly, but famines have been successfully met and conquered. There is still much hardship, much privation, and many unavoidable deaths when the rains fail, but millions are not swept away and whole districts are not depopulated. Steady progress has been made in developing the agricultural resources of the country and the area under cultivation is ever expanding, but the area of the land is limited and the opening up of new tracts is now becoming an increasingly difficult matter. Adverse seasons affect wider areas and agricultural distress, if less intense than formerly, is more widely diffused and occurs at more frequent intervals. To some the future appears full of difficulty, but to others these difficulties wear a rather benign aspect as carrying with them their own solution. They will force us to a more energetic course of action which will result in the more extensive application of improved methods of cultivation, in the more careful conservancy of water and a more perfect utilization of the resources of the soil. The ryot has managed to maintain his position practising methods which are the result of the accumulated experience of a hundred generations,—valuable experience it is true, but of very limited

range, and it requires no great amount of optimism to expect that if modern science and modern engineering skill are intelligently brought to his assistance an improved condition of things will result which will indefinitely postpone the evil day.

The better education of the agricultural classes is a primary necessity if they are to be put into a position to avail themselves of improvements and the Zamindars and big landholders must be taught to realize that their wealth and power and influence must be much more extensively devoted to the service of the people around them. The average ryot works on too small a scale and lacks the capital necessary for experiments and improvements and it is to the wealthy classes, whose craving for the acquisition of land is well-known, that we must look for pioneers in progress. Agriculture is the occupation of the great mass of the people, and is of such vast importance that it is entitled to be considered by itself when industrial matters are discussed. I have only alluded to it here because the main lines of advance are likely to be such as can only be made when the ryot can reckon on being able to secure the assistance of artizans and artificers of a class that are now only to be found in large towns.

There are few who would dispute the statement that during the nineteenth century the condition of the agricultural population had, on the whole, materially improved, and that it was mainly due to enlightened expenditure on public works of all kinds, but chiefly on roads, railways and irrigation works. These increased facilities for communication and transport internally combined with a similar improvement in the methods of inter-oceanic traffic which have so much encouraged the export trade in raw materials have however given an equal impulse to the import trade in manufactured goods from the West, and these goods have gradually displaced indigenous manufactures and reduced the

artizans of the country to a very impoverished condition. In Europe and America there has been a wonderful increase in manufacturing activity which is but faintly reflected in the cotton mills of Western India, the leather trade of Cawnpore, and the jute mills of Bengal. The bazaars of our towns and cities are full of imported wares, and year by year the tastes and needs of the people are becoming more and more Europeanized. The trade of the country is mainly in the hands of middlemen whose object is to export raw produce to the greatest extent possible and pay for it by importing manufactured goods. Obviously there is no other way—imports and exports must balance one another or the difference be paid for in specie or represent service of some kind; either administrative charges or interest on borrowed money.

The establishment of modern industrial undertakings requires co-operation on an extensive scale; except in a comparatively feeble way the natives of India do not place much faith in such commercial combinations, and it is only when the conditions are exceptionally favourable that capital flows freely from the West to the East. Consequently merchants in this country have found it easier and more profitable to be middlemen than manufacturers, and the whole of their energy and ability has been devoted to ousting the products of the indigenous artizan and driving him out of the trade that has been his livelihood and that of his family for many centuries. On a small scale, it is true, that something has been done to encourage the production of art wares for sale in Europe and America, but the business, though it bulks largely in the papers, is really an absolutely insignificant one, and the attempts to make it expand have only resulted in a sad falling off in the quality of the works produced.

The cry has been raised that the old artistic industries of India have been killed, but I have recently had opportunities of observing

that this is not so,—that they are only dormant, and that they flourish in a most unmistakable manner when circumstances are favourable to their development. The matter is very important, and it is perhaps desirable that I should adduce evidence in support of this statement. In the North Western Provinces at the instance of the Viceroy and with the support of the late Lieutenant-Governor, Sir Antony MacDonnell, a good deal of money has been spent in restoring the magnificent remains of Mogul architecture. The work has been done in a most creditable manner, and the Lieutenant-Governor has quite recently remarked, "It is noticeable that in all kinds of restorative work the Archæological Surveyor has tapped a vein of latent natural talent which has given excellent results. In fact the department has called into activity a school of artizans expert in this style of work. Many of them claim to be the descendants of the artificers who worked under the Emperors Akbar and Shahjahan."

In Mysore the new palace now in course of construction in the Fort finds employment for more than one thousand of the most skilled stone carvers, metal workers and wood carvers to be found in India, and the work turned out by them is equal to anything to be found in the country. Again, what is perhaps well-known to most of you, through the munificence of the Nattukottai Chettys the old Sivaite temples of Southern India are undergoing restoration. Many lakhs of rupees have been spent on the work which is being carried out in the old mediæval manner, and in all that has been done there are no signs of the deterioration so greatly deplored by those whose acquaintance with Indian art and artworkers is confined to curios in dealers' shops and ladies' drawing-rooms. In fact when good work is wanted it is always forthcoming, but unfortunately the demand for it is slight and fluctuating. The old native patrons have disappeared and any revival of

the old art industries resolves itself almost entirely into a question of finding new patrons. There is reason to believe that it would not be difficult to divert some small portion of the golden showers, under which art flourishes in the West, to revivify and stimulate into renewed activity the neglected and impoverished workers of India.

Some months ago I submitted a scheme* for the consideration of those gentlemen who control the funds that have been raised to commemorate the Jubilee, and the Memory of Her late Imperial Majesty the Queen-Empress, but I have not heard that the very practical question of what they are going to do with the money has yet come before them. I hope presently to show that, with the very limited resources at their disposal, they cannot hope to launch with success any very grand project for developing Technical Education in this Presidency; but I think, and so do several other people whose opinion is more than ordinarily valuable, that the creation of an intermediate agency between the art workers and those who desire to possess their works and are willing to pay for them, would be an extremely useful and very practical way of assisting an interesting section of the community, whose supposed extinction or at any rate hopeless decadence has been somewhat prematurely mourned.

The persistence of hereditary skill through long periods adverse to its display is an interesting psychological phenomena and a factor which, I think, is of great importance in the general question of Industrial Education which we are now discussing. Assuming its existence, the rational procedure seems to be to afford as much encouragement as possible to its growth. If we are

* Since this paper was written, the scheme has been adopted by the Joint Committee of the two funds and the plans for a suitable Exhibition Hall have been prepared and approved of.

to have Schools of Art and of Art Industries, let them be places where the hereditary craftsmen congregate, where the talents of the more gifted are utilized to instruct the pupils and where every opportunity is given for latent sparks of genius to be fanned into flame. I would not absolutely restrict them to caste men, but I would not specially encourage the admission of outsiders, as my experience, so far as it goes, is not favourable to the utility of giving or attempting to give an artistic training to every one who, from some accidental cause or other, finds it convenient to become a student of a School of Arts. Such an institution should have for its object the production of works of art and that it may not be a burden on the community and that it may go on producing indefinitely; it is absolutely essential that it should be run on intelligent business lines. I do not think it is necessary to go to Europe for art instructors—South Kensington will do India very little good and may do much harm. The old art was very beautiful because it was of spontaneous growth—inevitably it must undergo change through the contact of West with East, but let the influence be gentle and insensibly exercised. The result may be inharmonious and grotesque for a time, but sooner or later the natural genius will be produced who will found a School of Art expressing naturally and simply the ideals of the people from whom he has sprung. Art can only really flourish when it meets with local recognition, and though, I think, it is quite possible to work up a not inconsiderable foreign demand for the products of Indian Art industries, yet it will be an unsatisfactory condition of things so long as it rests on such a basis. What is wanted more than anything is to educate our wealthy classes to a true appreciation of the worth of the artistic productions of their fellow countrymen—to an abhorrence of French mirrors, musical boxes, glass chandeliers and gilt gimcracks. We ought to have a permanent exhibi-

tion of native art industries in suitable surroundings, and it should be a place which should attract, and attracting, educate those people in this Presidency who are fortunate enough to be able to indulge in luxuries, but who at present are filled with childish admiration for what is bright and glittering.

The example that has been set in Mysore is an excellent one, and it is to be hoped that, when the work is finished there, the art workers and artizans may find others wanting their services. Our educational system is sadly deficient in the way in which it completely and entirely ignores the influence of art and artistic surroundings, and I venture to suggest to the Victoria Jubilee and Memorial Committee that it is within their power to do not a little to remedy this evil if they will apply their funds to rendering better known the latent artistic skill which yet exists and which lies dormant simply for want of opportunity. It is ideas such as these that we are trying to give practical expression to in the School of Arts in Madras, and I am glad of the opportunity of publicly explaining them because progress is necessarily very slow and because to the casual visitor the art work that is being done there is somewhat obscured by the prominence of certain purely industrial experiments which have been going on for some years past.

I have already briefly alluded to the way in which during the past century the indigenous industries of the country have been crushed by the competition of imports, and I must now ask you to consider with me how far by means of State institutions steps can be taken to remedy the existing state of things. The evils are fully recognised, and for the past 15 years a cry has arisen, constantly increasing in volume and intensity, for a State-aided system of Technical Education to remedy them. In the words of Lord Curzon's address to the Educational Conference at

Simla, "Here in India there seems to be a general idea that in Technical Education will be found the regeneration of the country. Technical Education is to resuscitate our native industries, to find for them new markets, and to recover old, to relieve agriculture, to develop the latent resources of the soil, to reduce the rush of our youths to literary courses and pursuits, to solve the economic problem and generally to revive a Saturnian age. The imagination has been struck by the alleged triumphs of Germany, and by the unquestionable enterprise of the youth of Japan." In Madras, I think, we must plead guilty to this indictment and to the fatuous folly, with 15 years' experience barren of all result, of still thinking that it is possible some *deus ex machina* may arise who will with the meagre funds that have been raised to commemorate the life and reign of the late Queen-Empress, devise a scheme of Technical Education which will introduce an era of industrial prosperity. That nothing has been done is not surprising, but it is surprising to find how many people still think that it is the fault of Government and the State Department of Education that the industries of the Presidency are not flourishing and that profitable employment has not been found for the congested population seeking a scanty and precarious livelihood on a barren soil.

What are our natural resources, out of what materials are industries to be created, have we neglected them, or is it the poverty of our surroundings which prevents us from doing anything? Into a detailed reply to these questions it is impossible for me to enter, but broadly speaking the plains of the South of India may be described as a poor country—fertile where it is artificially watered, but barren elsewhere. Its iron ores are its only mineral wealth and their tantalizing abundance is rendered of no avail by the absence of fuel. The climate enables existence

to be dragged out on very little and the necessaries of life are few and simple. Consequently labour is cheap and it is with this asset, and this only that we can hope to achieve anything. The artizans are intelligent, skilful and when properly instructed capable in well-organized factories of holding their own in some directions against the utmost efforts of machine producers. Nearly all the raw material they use has to be imported and the protection that they get in competition with imports due to the 5 per cent. duty and the cost of freight is practically very small. The weavers form the bulk of the artizan community, but the workers in wood and metal are also very important. With the artizans of the building trades we need not concern ourselves as they suffer from no direct competition, and their prosperity is dependent entirely on the well-being of the whole community. These artizans belong to well-defined castes and their occupations are in the main hereditary, though the son of a blacksmith may become a carpenter or a coppersmith and *vice versa*, but the son of a weaver is generally a weaver. It is difficult, if not impossible, for outsiders to become apprentices to these trades in the bazaars, and what is in reality a healthy trades union has prevented internal competition in the country from reducing the artizans to the level of the poorest agricultural population.

Such attempts at Industrial Education as have been made, and in what follows I must specially exclude the School of Arts which, from its foundation 50 years ago, has occupied an altogether exceptional position, have had for their main object the training of people belonging to the non-artizan classes. The earliest schools were started by missionaries for the training of their protegées and they have met with a certain limited measure of success, but the total number of Native Christian artizans outside the special establishments of the Basel Mission is

extremely small and is not a factor of importance in the industrial position of the Presidency. Certain District Boards and Municipalities have devoted part of their funds to the advancement of Industrial Education, but the methods pursued have been extremely crude and the results incommensurate, except in one single case, with the expenditure that has been incurred. The usual procedure was as follows: A Headmaster or Superintendent was appointed without any regard to his fitness for the position, but chiefly because he was willing to accept the modest pay offered him—pupils were gathered in from the highways and byeways by the offer of attractive scholarships. Maistries were appointed to teach certain trades, usually carpentry, blacksmith's work and rattan work. Efforts were made to get orders for work and the European and official element of the population appealed to for support. So far as I am aware no attempt was ever made until recently to train the boys in these industrial schools on work other than that required by Europeans—the huge native markets around them were entirely neglected and the schools languished for want of an outlet for their productions. It would serve no useful purpose to unduly dilate on the imperfections of these experiments in Industrial Education. They did not achieve the objects with which they were started, but they attracted attention to themselves and offered opportunities for experiment and enquiries and in that way some good has come from them.

The Industrial School of the future has yet to be evolved, but in Madras we have accepted, at any rate tentatively, certain general principles regarding their functions and the way they should be worked. The schools may be divided into three main classes: (1) Those established for the purpose of training boys as artizans who are not artizans by caste and who consequently

have no opportunity of picking up a trade in any other way. The bulk of these schools will be of a sectarian character, such as the Anjuman Industrial School for Muhammadans or the various Mission Schools. They will follow along established lines and if efficiently conducted should supply a useful stimulus to the artizan classes by the introduction of an element of competition which should have a beneficial effect.

(2) Central Industrial Schools primarily intended for the benefit of the recognized industrial classes and working with the object of improving the industries of the country. These schools are never likely to be very numerous and they will be of necessity mainly in the hands of European experts. The object is not so much to train boys, though that of course will be done, as to provide a supplementary course of instruction to the training which artizans now receive in their own homes. In them a large amount of experimental work will always be in progress, new ideas will be tested, new processes tried, new tools brought to the notice of the trades and generally the endeavour will be made to foster private enterprise by help in any direction that may be feasible. There is no intention to gradually build them up into important manufacturing establishments, but they will be conducted on a scale just large enough to render them thoroughly efficient training institutions not only for workmen, but also for poeple who will afterwards become foremen and managers of works. With vested interests there is no intention that they should compete, and the policy to be adopted in their management will be to bring them into as intimate association as possible with existing undertakings. Of necessity they must have a business side for the disposal of their outturn and that will be conducted on rational business principles having in view that the end and object of the Schools is not a dividend on the capital invested in

them but the promotion of the industrial prosperity of the country. The industrial side of the Madras School of Arts is at present the only representative institution of this kind in India and so far its operations have been mainly confined to the establishment of a school of metal work which conducted on the lines I have indicated above has met with sufficient success to justify us in thinking that a development of the same policy in regard to other industries may be of great assistance to the struggling artizan communities. Into the details of the work that has been done in the past or that is contemplated in the future this is hardly a fitting occasion for me to enter, but those of you who are sufficiently interested in the matter may easily pursue your enquires at the School where information can be freely obtained. It will suffice to say that, during next year I hope to be able develop the weaving section that has been recently started. From the experimental work that has been done and is now in progress, it is evident that there is great room for expert assistance, but whether we shall be able to materially improve the condition of the great weaving population of India is a matter which is influenced by so many and such very complex factors entirely beyond our control that it is only the very urgent necessity for doing something that has led us to contemplate attacking such a series of difficult problems.

(3) The third class of schools will be to a large extent offshoots of the second. It is not desirable that we should set up, as has hitherto been done, Industrial Schools to teach what is already taught in the bazaars, but there are many places where industrial knowledge and skill in certain trades is in a backward condition, and it is important that the artizans should everywhere be taught to work on the most advantageous lines and that the most should be made of their cheap labour. The Central

Industrial Schools can only come into contact with a comparatively small number of artizans and when by experience it is ascertained that in any branch of industry a feasible improvement has been effected, branch institutions are required to diffuse the knowledge among all who are affected thereby. A typical school of this class exists at Madura and is maintained by the District Board in a very efficient condition. The superintendence and management of these schools should invariably be in native hands, and it will be one of the functions of the Central Schools to train the science graduates of the University and the passed pupils of the Higher Technical Colleges and Schools, so that they may be able to undertake this work.

The cost of establishing these schools will be considerable as they will have to be provided with workshops and equipped with good machinery to assist and supplement hand labour. The scale on which they will operate will be as small as is compatible with the attainment of the end for which they will be started. Yet the turnover must in all cases be considerable and the working expenses fairly heavy as it will only be in exceptional cases and for short periods that the schools will be able even with the most skilful management to fully pay their way. The majority of these schools will only deal with one industry or with one associated group of industries, so that their whole resources may be concentrated on a definite object and not, as has hitherto been the case, frittered away in attempting to deal with too much. There are many questions connected with the organization and management of these schools which have been the subject of much discussion and it is not, I think, advisable that any hard and fast rules should be drawn up to deal with them. It is essential at any rate for the present that the schools should have as elastic a constitution as is consistent with proper control

and that each should be placed in a position so that its superintendent may take full advantage of any favourable local circumstances that may arise. The most essential requisite is that they should be looked up to by the artizan community throughout the country as places where work is being visibly carried on for their benefit, and the measure of success which they achieve should be largely gauged by the voluntary support which they receive from the working classes. So long as the attendance of pupils can only be secured by the grant of stipends and scholarships, so long we may take it for granted that they are not supplying a recognized want in a way which is useful to those for whose benefit the institutions have been started. The artizans, however, are very poor and it is obvious that they must earn sufficient to enable them to live, and the gradual abolition of scholarships should be accompanied by the introduction of a system of paying wages, which wages should represent the actual value of the labour expended. It is not young children so much as young workmen that the schools should attract and the instruction and practice in trade operations which the schools must supply should be such as to give the pupils valuable experience which will readily find a market.

The question as to the best means of disposing of the finished productions of these schools is not such a serious one as is generally supposed, since the main objection which has been raised—interference with private trade—will be easily avoided if the fundamental principles which have hitherto guided our work are strictly adhered to. The object of these schools is to create new industries, to improve old ones, to extend the range of industrial operations and indicate the possibilities of new markets. Importers of foreign manufactures may suffer, but it is to be hoped that the creation of an export trade in hand manufactures may

compensate them for any loss they may sustain, and it is certain that if the mercantile community can be brought to see the possibilities of export business and will proceed to develop them with the same energy and ability that has been displayed in their business operations in the past, there will result an immense improvement in the industrial condition of the country.

DISTRICT BOARD INDUSTRIAL SCHOOLS.

GENTLEMEN,—I am sure that you will all agree with me that the report we have received this afternoon from Mr. G. Subbuswami Aiyar, the Superintendent of this school, is a record of much excellent work, done under circumstances the difficulties of which few are able to appreciate except those who are connected with the work of such an institution as this. Industrial Schools are of comparatively recent date in India and each step that we take in the development of them has to be done with care and consideration and to a certain extent tentatively. There has been in the past and there will be, I am sure, for a considerable time in the future much difficulty in getting suitable teachers, and in addition through want of funds the difficulties of such institutions in the beginning are very great. We have heard how from the amalgamation of two comparatively small classes, the old Municipal Industrial School and the Board Normal School, Mr. Subbuswami Aiyar six years ago commenced work in this place and the result of it we see to-day. From 18 students in the Industrial Classes the numbers have gradually increased to 88, and I have no doubt they will increase to a still larger number when the funds are much larger and the accommodation more ample.

Occasionally I am deputed to visit and report on Institutions of this class and generally I find the task a very easy one. For in

* Speech delivered at the distribution of prizes to the pupils of the Madura Technical School, July 1896.

most cases there is seldom much difficulty in finding out faults and in suggesting material improvements which will occupy the attention of the responsible Managers for some time to come. But here I am very glad to say it has been otherwise. During the last three days I have had ample opportunities to inspect the work which is going on in this school, and I think I can tell you without any exaggeration that I have no fault to find with what is being done.

It seldom happens to me to have an opportunity of addressing any very large number of educated native gentlemen who are interested in educational matters, and I think your presence here shows your interest in the subject. I therefore propose to occupy your attention for a few minutes with some ideas which have been suggested by the working of this institution. I am asked in connection with these industrial classes whether they are doing any real good in the country, whether the training that is given in them is better than can be got in the bazaar, and whether, if the training is better, there is any real demand for artisans who are better workmen than the ordinary bazaar artisans. Now, in other parts of the world such as in Europe and America, Industrial Schools have been tried on a very large scale, and those of you who are acquainted with their history will know that they have been regarded more or less as failures. But in India the circumstances are entirely different and for several reasons the Industrial Schools, such as this institution here, have a very wide field in front of them. In the first place, I think most of you will admit that you want work done at times which you cannot get done satisfactorily in the bazaar. As far as I am able to judge the bazaar artisans have not been keeping pace with the development which is going on in most other respects in this country. Each trade belongs to a particular

caste and these trade castes are perhaps more than any others conservative in the extreme degree, so they still carry on their work to a large extent with the tools and in the manner of their forefathers and they are not altogether able to meet the demands which the modern social and material development of the country requires. In this connection, I may perhaps be allowed to give you an example. For some time past I have been more or less interested in the question of improving the means of raising water for irrigation from wells and in the extension of garden cultivation. It has been my duty on several occasions to examine the machines which were supposed to be, and in some cases were, a distinct improvement upon those that are at present in use, but they are too complicated for ordinary ryots to deal with, and the country does not possess the necessary artisan's labour to keep them in order and to repair them. There is no doubt that, if there were a competent body of blacksmiths and carpenters such as are trained in this institution, very much might be done to improve the agricultural prospects of greater part of the country by the introduction of improved means of lifting water, as the ryots would then find no difficulty in getting slight repairs done and they would readily adopt them. I have already mentioned that the trades are confined to particular castes of men, and those outside these trade castes have few opportunities of learning a trade, whilst those of one trade are similarly situated if they want to change to another trade. For instance, there are a very large number of poor Brahmins in this part of India who are more or less ashamed to work, but I am afraid they are not ashamed to beg. It would undoubtedly be an immense advantage to them if they could throw away their old ideas of the unworthiness of manual labour and send their children to these schools and

give them an opportunity of learning a trade whereby they could earn an honest livelihood. Many ryots have large families and comparatively small holdings of land and they must be put to very great difficulty in providing suitably for their children. In some cases, they sacrifice their family acres to send a son to School and College in the hope he will get a Government appointment, a clerkship, or rise to be a Pleader or Vakil in a Court. But many of them meet with failure and the whole of the money spent on their education is practically wasted. If they do not meet with a certain amount of success, the training they get is of very little value to them, and only unfits them for and makes them despise the quiet life of their native villages. In many cases it would be far better if those ryots were to send their sons to Industrial Schools to give them an opportunity of learning a trade or business. The prospects of skilful artisans are by no means small; if they have a good education in addition to being good workmen there is no reason why they should not rise to be masters of small industrial establishments such as exist in other countries.

Then, again, Industrial Schools serve the very useful purpose in promoting the diffusion of mechanical skill throughout the country. In Bellary they have very good blacksmiths, on the West Coast and in Madras there are very good carpenters, and in Kumbakonum metal workers are celebrated for their skill. But in other parts they are very much below the level of the work done in these particular places, and it will be the duty of Industrial Schools to try and raise the standard of manual skill to the same high level all over the country, and for this reason I am glad to see in the report that the number of artisans in the school is slowly but gradually increasing.

Although the industrial side of the school is, as I have already said, doing very good work, there is an Agricultural Department attached to it in a very loose kind of way which is undoubtedly in a very unsatisfactory condition, and it is so for reasons over which the Superintendent has no control whatever. Now it seems to me at the present time that the development of this Agricultural Department is one which is needed more than any other. It is only quite recently that the waters of the Periyar valley have been turned into the Madura District and the country to the north of Madura blessed with the presence of a bountiful and certain supply of water; and the change which has been introduced must necessarily be followed to a very large extent by changes in the methods of cultivation by the ryots. It therefore seems to me that it is a great pity that in Madura there is no model farm—I do not mean an experimental farm, but one in which the ryots who are changing their methods of cultivation can see what is being done in other Districts. It would be a very good thing, indeed if arrangements could be made to follow and practise the method of cultivation adopted in Coimbatore and Tanjore.

I believe there are several members of the District Board present, and as the maintenance of the school depends upon the funds which they have under their control, they will be glad to hear from me my opinion in a non-official way on the various departments of the school. But first I should like to draw your attention to the fact I have frequently observed that there is a tendency after a few years to grudge meeting the gradually increasing expenditure for the proper development of such institutions as this, and especially so when a long time must necessarily elapse before any very definite results can be seen. You may take it from me that it requires from 5 to 7 years to train an

artisan to be a master craftsman, and it is utterly impossible for you to expect that any very great results should be visible for some years to come; and as the institution has only been in existence some six years it will take 3 or 4 years more before you can perceive any marked distinction between the artisans which are turned out in this Industrial School and those which are trained in ordinary way in the bazaars.

There is one point about this institution that I do not exactly like, and that is its name. It is called a Technical School; whereas it is really an Industrial School, and I think it would be better to recognize the fact that from beginning it is an Industrial School and intends to remain as such. The humbler the name you give to this institution the less perhaps is expected from it and the more likelihood there is that what you expect will be attained. A Technical School is one in which something more than the mere teaching of a trade is undertaken, and at present and very wisely too, the efforts of this institution are entirely confined to the teaching of trades in the way they ought to be taught, and it would be better to leave things which are truly technical to other institutions which are better situated and have larger funds at their disposal for carrying them out.

Now, in connection with the Carpentry class, those of you who are able to appreciate the difference between good and bad joinery will undoubtedly admit that most of the wood work done here is a very great deal better than can be obtained in the different bazaars of Madura; and there is no doubt whatever that the training which the boys are receiving is far better and is far more likely to turn out good workmen than that which they would obtain under the old methods in the bazaar. Very frequently the complaint is raised that the boys are taught to use tools in ways which they are not likely to keep up afterwards.

That is not altogether a fact. Even in the bazaars it has been found by experience that English tools are often cheaper in the long run than native articles, and there is a gradually increasing tendency on the part of artisans to adopt such English tools as they can get. In Industrial Schools like this the boys are taught regular habits from the beginning and are subjected to a salutary system of discipline that enables them to turn out better work in much less time, and the consequence is that when they leave the school there is a demand for their services as they do more and better work, and consequently they earn more wages than men who have not enjoyed such advantages. In the Blacksmith's class they are doing very good work, but the difference, however, is possibly not so great as it is with the carpentry class. In Industrial Schools it is very difficult to really turn out first class blacksmiths because of the few opportunities they get for heavy work.

In the metal working department, I understand from the Superintendent that they have turned out a large amount of work suitable to the market in Madura itself. And in this connection I should like to suggest to those connected with the institution, that they should make some small experiments in introducing a new metal for this class of work, which, as far as I know, has not yet been tried in India, but which would be well suited to native requirements. I believe that you use silver plates, when you can afford them, and that when you cannot get them you content yourselves with plantain leaves. Most of your cooking vessels are made of sheet brass and are not altogether satisfactory as they require, I think, frequent *calloying*, and it would be a very good opportunity for an Industrial School like this to try and see whether Aluminium would not suit the requirements of the wealthier classes of

natives who can afford to pay a little more for their household utensils than they do for the brass and copper ones which they use at present. I think if an opportunity is given to the Superintendent to procure a small quantity of this metal he might be able to introduce a new industry—aluminium working—into the District, and it is not improbable that once its many valuable properties are appreciated, its use will increase to an extent you can at present hardly conceive.*

The only class in the institution which is not altogether a satisfactory one is the rattan class, that partly for this reason that the skilled rattan workers cannot command very high wages. In this connection I should like to point out that it is more suitable for boys suffering from slight physical infirmities than for good, strong and healthy boys. And if as ought to be done the boys are not admitted at too early an age to discriminate between those who are physically weak and those who are physically strong, the policy should be adopted of putting those boys who enjoy good health to trades in which they can command high wages afterwards and in which they have an opportunity of utilising their muscles.

I have noticed with considerable pleasure the prizes and I commend the judgment which has been shown by Mr. Subbuswamy Iyer in selecting them. It is a good idea which should be followed in all such cases to award prizes of such things as tools, with which the recipients can afterwards work and they should be in every case tools of the best quality that can be procured so that they may prove satisfactory. I think it is a matter for congratulation to see that a very large number of gentlemen have given prizes to the boys, and the example, I hope, will be followed in

* The experiments here suggested were subsequently carried out in the School of Arts, Madras, and the Madura School was the first mofussil Institution to establish an Aluminium Department.

future years. An institution like this is capable of doing an incalculable amount of good to this District if it is worked on proper lines and if time is given for its full development. I am perfectly aware that the District funds are limited, and that there are urgent calls upon them, and that those who have control over them have to discriminate in the manner in which they are disposed of. Educational institutions can get only a certain share. This opens to the wealthier people in the Town or District a valuable opportunity to display their public-spiritedness by helping on a work which is so likely to materially develop and increase the prosperity of the District. It would be, I am sure, a source of very considerable satisfaction to all concerned in the management of this institution, if from time to time they received liberal assistance from private persons in various ways, such as presents of new tools or new apparatus.

It only remains for me to congratulate Mr. Subbuswami Iyer and his subordinates who have co-operated with him, on the very admirable work they have done, and I wish them a continuance of prosperity and success which they have deservedly earned.

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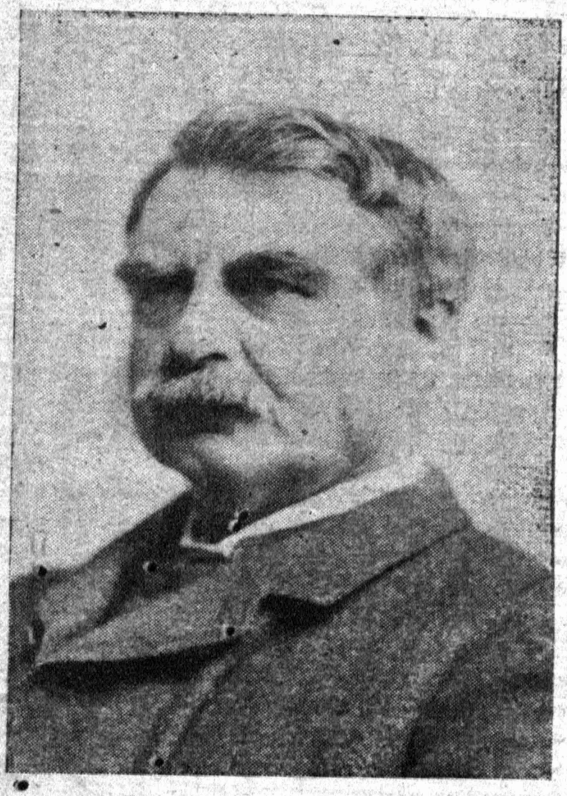

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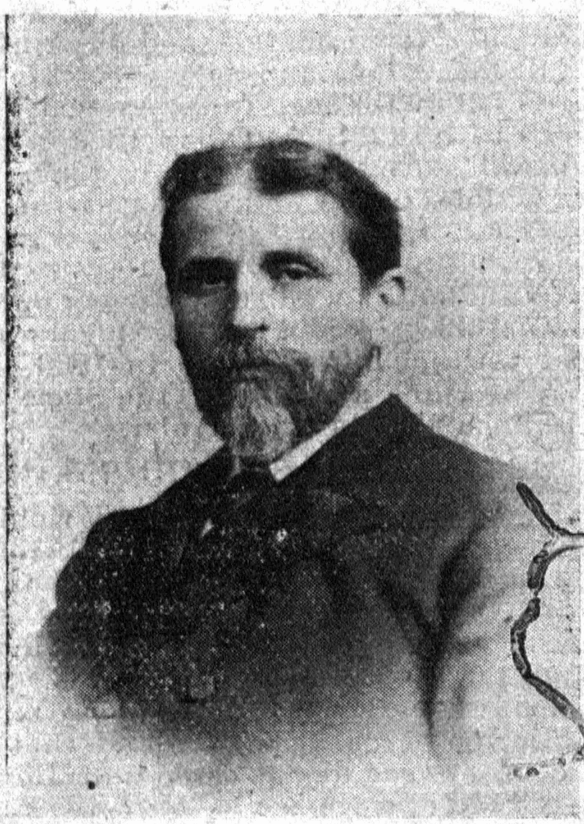

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